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SOME STUDIES OF CHILDREN'S INTERESTS IN SCIENCE MATERIALS.

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In an attempt to get some data on the nature of children's interests in animals an experiment was made in schools in three cities and the results recorded in an unpublished thesis. Since that time the same method of collecting information has been extended to three other cities and seven rural schools. In the same investigation an attempt was made to obtain data regarding children's interests in three phases of science work, namely, plants, animals, and physical phenomena. The results as given in the thesis and those obtained in the succeeding investigations are included in this report.

PURPOSE OF THE EXPERIMENT.

The inclusion of any particular science material in any of the grades is almost invariably justified on the ground that it is of peculiar interest to children of that grade. If special emphasis is given plant life in the fourth grade it is because children of this grade are "most interested in plants." In another fourth grade in the same city animal life may be the thing emphasized for the same reason. Probably in most instances the peculiar interests of the teachers are the real guiding principles underlying the organization of elementary science materials. In one of the schools investigated the teacher of the second grade emphasized the study of the life history of ants because she had discovered that pupils of that grade were "most interested in the life histories of animals." In the fourth and fifth grades in the same building they were studying the life histories of animals for the same reason. Various grades have made special studies of fish, snakes, trees, chickens, spore plants, spring flowers, pets, electricity, work of running water, seed dispersal, plant propagation, each being

justified on the basis of peculiar interest to the group of children concerned. Elementary science in some schools means a study of animals and animal life, in others very little of this is done, the main emphasis being given to the study of plants and plant life. In most of the schools plant life and animal life are the only phases of the work included in the course of study. It was the purpose of the investigation to discover whether by experimental procedure data might be obtained which would give evidence regarding the nature of (I.) children's interests in animals and in (II.) the three phases of science work, plants, animals, and physical phenomena.

I. Children's Interest in Animals.

The Animal Used.

In planning this part of the experiment it was thought best to use some animal unknown or little known to most of the children. Special attempt was made to conduct the work as nearly as possible under regular school practices. One of the most widely distributed of the North American salamanders was chosen. The animal is technically known as *Necturus maculatus* and popularly known by such names as "Water-dog," "Mud-puppy," "Water Newt," "Mud Eel," "Gilled Salamander," and "Water Lizzard." In maturity it reaches a length of a little more than a foot. It is a smooth, slimy animal possessing an elongated, flabby

trunk, supported by four weak legs, which seem out of all due proportion to the rest of the animal. The flat head is connected to the trunk by a short, slightly constricted neck and is equipped with two small eyes and a very large mouth. On each side of neck is a three-parted external gill. The animal has a long, compressed tail, bordered with a continuous median fin-like projection or fold of skin. It lives in the mud, weeds, and rocks at the bottoms of streams, feeding on crayfish, frogs, worms small fish, and other water forms. The animal, although repulsive in appearance, is absolutely harmless. In some localities it is superstitiously supposed to be poisonous. In early spring it is often caught on hooks by fishermen. I have known of instances of fishermen cautiously killing the "deadly thing" with a club before removing it from the hook. To one who has never seen it and who has a horror of "creeping things" the animal would undoubtedly present a very unattractive appearance.

Method of Conducting the Experiment.

Throughout the whole experiment the work was done in classrooms during regular school hours. A live animal was used. It was housed in three inches of water in a large, rectangular glass aquarium. A repetition of the instructions given the pupils just prior to the demonstration will at the same time explain the plan and show the procedure. The instructions were given orally as follows: "Just outside the door in a large glass jar I have an animal in some water. I am going to bring it into the room and let you see it. No doubt as you look at the animal there will be many questions you would like to ask concerning it. If I am able to do so I shall tell you all you wish to know about it. Before I bring it in, however, there are some favors I wish to ask of you. As you look at the animal you are to ask no questions of each other, of your teacher, or of me. You are to make no suggestions whatever; simply look and think but keep quiet. After you have looked at it for a while you are to take your seats and write as many questions concerning it as you wish. If there is only one thing you wish to know about it, write one question. If there are twenty things you wish to know, write twenty questions. Do not be afraid of asking too many questions. After your papers are collected I shall try to answer the questions you have asked." (In the first and second grades the pupils were told that the teacher and the writer would come to them and they should whisper their questions.)

The animal was then taken into the room, placed on a chair, and about seven pupils at a time were permitted to come and look at it. Three minutes were given each group for observation after which the pupils were requested to take their seats, write their questions, and another group permitted to observe the animal. After the last group had seen it, in all save a few instances the animal was taken from the room. This method gave the first groups more time for writing their questions; however, ample time was given the last group for writing all the questions desired by the pupils. After the papers were collected a short talk was given concerning the animal; its name, where it could be found, its life history, function of some of its parts, its habits, etc. In order to make sure that no questions were overlooked in the talk, the pupils were given opportunity to state any of their written questions which had not been discussed. In the Elementary School of The School of Education, University of Chicago, grades six to eight were called together for a morning

assembly in which the discussion of the animal was given. Other than this, the procedure was as stated above.

The precautions in having the pupils in grades one and two whisper their questions and in permitting no remarks during the observation period in the other grades were taken in order that the individual reactions of each pupil, as free as possible from outside influence, might be obtained. An oral suggestion by one pupil during the observation period might result in the initiation of many questions in the minds of the other pupils. It is not meant by this remark that numerous questions were not desired, but that the questions obtained should be the result of each pupil's own reaction. The questions thus obtained were taken as a fair indication of the children's various interests in the animal.

Before taking up a discussion of the results it will probably be in order to list the various schools in which the experiment was tried.

School Types Used.

School A. The Elementary School of The School of Education, University of Chicago. This is a private school whose pupils are accepted from a list of applicants by the administrative officers. This manner of selection places these pupils as a "selected group." The elementary science of the school at the time of the study was under the direction of the Natural Science Department of The School of Education. The work in the sixth, seventh, and eighth grades was at the time of the experiment taught by a special teacher of the subject. In the first, second, third, and fifth grades the science work was done by the regular teachers in charge of the grades.

School B. The Emerson School, Gary, Indiana. In this school building were found all the grammar grades and the four years of the high school. The science teaching was done by special teachers; one had charge of the work in the first five grades, and the regular teachers of botany and zoology in the high school had charge of the work in the remaining grades. In all the grades above the fourth the boys and girls were taught in separate classes.

School C, Oak Park, Illinois. This suburb of Chicago is characterized by a large percentage of good homes and prides itself on its excellent schools. In the ward school in which the experiment was tried the science was taught by the regular grade teachers.

School D. A school in a congested Jewish district in Chicago. This school is located in one of the most congested regions of the

whole city. The principal estimates that at least ninety-five per cent of the pupils in the school are Jewish. It is far removed from field conditions and little science teaching was attempted at the time of the experiment.

School E. A composite made up of seven rural schools. These schools are located in Coles County, Illinois. Much of the township in which the schools are located is in the rich, black prairie region of the state. The Kaskaskia River flows through part of the district and exposes many square miles of the clay subsoil, hence in the township are found both rich and poor farming regions. Four of the schools are located in the rich farming region and three in the poor. They are all one-room schools. At the time the experiment was made science was taught in none of them.

School F. Goshen, Indiana. A residential town in northern Indiana with a population of a little less than ten thousand. It had good school buildings, a progressive superintendent, and good teachers. Science was taught in each grade by the teacher in charge.

School G. DeKalb, Illinois. At the time the experiment was made there was a very close cooperation between the State Normal School located there and the city schools. The Head of the Training Department in the normal school was also the Superintendent of City Schools. The experiment was tried in the lower grades of the training school and in the upper grades of one of the ward schools of the city. Science was taught by the regular teachers.

This list of schools presents a wide range in types; from a school in the most congested district of a large city to schools in a secluded rural district; a school in a new city with a new school system organized on nonconventional lines to one of long standing in which the superintendent took great pride in the long tenure of most of his teachers; a school in which most of the pupils were of well-to-do parents and one in which most of the children were of parents of meagre means; a school in which nearly all the pupils were of one race, one in which there were an exceedingly large number of nationalities, and others in which nearly all the children were of native-born parents; a school having a definitely organized course in elementary science with special teachers to do most of the teaching of it, one having special teachers to do all of it but with no definitely organized course, some having the work taught by the regular teachers and still others having no elementary science at all.

Sample Pupil Responses With Classification Headings.

Below are some sample papers received from pupils. The spelling is given as it appeared on the papers. The words in parentheses following the questions indicate the classification given the various questions.

Third Grade Pupil:

What is its name? (Identification)
Is it from the South? (Geographical Distribution)
Was it brought from the wild country? (Geographical Distribution)
Where did you get it? (Environment)
How old is it? (Life History)
What does it eat? (Food)
Can it swim very well? (Movements)
What all can it do? (Habits)

Fourth Grade Pupil:

What is the animal? (Identification)
What does it eat? (Food)
Where does it live? (Environment)
Where did you get it? (Environment)
What does it do? (Habits)
What kind of food does it eat? (Food)

Fifth Grade Pupil:

What kind of animal is it? (Classification)
What does it eat? (Food)
What do you call it? (Identification)
What has it got on its ears? (Gills)
What has it got with him? (Unclassified)
From what country did you get it sir? (Geographical Distribution)
Does he drink the water in which he lives? (Food)
Is he very old? Or is he young? (Life History)
What is he man, or women? Please answer me because I want to know. (Sex)

Sixth Grade Pupil:

What is the name of the animal? (Identification)
What are those things by his ears? (Gills)
What makes them move all the time? (Function of parts)
Must it only live in the water? (Adaptations)
Where are those animals found? (Environment)
Must you change the water every day? (Unclassified)
What does it eat? (Food)
Does it stay in one place all the time? (Habits)
Can you tell how old it is? (Life history)
Has it any teeth? (Structure)
Has it any ears? (Structure)
What time of day does it go to sleep? (Habits)
Can it swim? (Movements)
What kind of climate does it stay in? (Geographical Distribution)
How did you catch it? (Unclassified)
What country does it stay in? (Geographical Distribution)
How long is it? (Size)
Can it walk around? (Movements)
How long does it stay in one place? (Habits)

Eighth Grade Pupil:

What are the six pieces on both sides of the head? (Gills)
Do they act as breathing apparatus or are they just his ears? (Function of parts) (Structure)
Where are these animals found? (Environment)

What is its name? (Identification)
In its course of life does it go through different stages of life? (Life history)
What are those lines on the under side of its body? (Structure)
Do they act as helpers to move, or is it just because of its fatness? (Function of parts)
Is it related to the crocodile? (Classification)
From what species of animal does it come? (Classification)
Is it a mammal or not? (Classification)

In tabulating the questions it was found that they concerned the following things: Identification, Classification, Environment, Food, Life History, Adaptations, Movements, Geographical Distribution, Use, Habits, Structure, Gills, Function of Parts, Enemies, Abundance, Sex Color, Evolution, Dangerousness, and Teleological questions.

Number of Pupils Participating.

The following tables showing the numbers of pupils in the various grades participating in the experiment, the numbers of questions asked in these grades, and the average numbers of questions per pupil in the various grades is needed for a proper interpretation of the graphs which follow.

Schools and Number of Pupils Involved.

Grade	Number of Pupils	Number of Questions	Average per Pupil
1	156	361	2.3
2	131	365	2.8
3	197	738	3.7
4	238	1275	5.4
5	192	1110	5.8
6	237	1345	5.7
7	322	1843	5.7
8	243	1292	5.3

	First Grade	Second Grade	Third Grade	Fourth Grade	Fifth Grade	Sixth Grade	Seventh Grade	Eighth Grade	Total
U. E. S.	31	46	28	43	43	25	39	49	304
Oak Park	35	17	30	32	32	21	50	36	253
Gary	29	8	49	33	18	18	68	......	223
Chicago	28	34	33	41	39	45	41	43	304
Goshen	....	....	11	20	18	89	82	81	301
Rural	12	9	30	24	14	17	4	19	129
De Kalb	21	17	16	45	28	22	38	15	202
Total	156	131	197	238	192	237	322	243	1,716

A Tabulation of the Data in the Form of Graphs.

The following graphs show the result of the tabulation of the data collected. They are used to indicate the interests of the pupils as manifested by the questions asked. The grades are designated by Roman numerals placed at the bottom of the graphs and the indicated per cent of interest in the various phases by Arabic numerals placed at the side. This "per cent of interest" is found by using the number of pupils in the grade

as a base and the number of questions asked concerning the phase in question as the per cent. For example, if in a grade of twenty pupils, ten questions pertaining to "Function of Parts" were asked the graph should show a fifty per cent interest in this phase, should forty questions have been asked then the graph should show a two hundred per cent interest. A central tendency was found by similarly using all the questions pertaining to any particular phase asked in all the schools in a given grade. This central tendency is designated by a heavy continuous line. Cross hatchured lines indicate coalesence of two or more graphs at that point.

The various schools are designated in the graphs by the following lines:

School A. University Elementary School. Continuous fine line.
*School B. Gary, Indiana. Dash and three dots.
School C. Oak Park, Illinois. Dash and two dots.
School D. Chicago, Illinois. Dash and one dot.
School E. Rural Schools, Coles County, Illinois. Dashes.
**School F. Goshen, Indiana. Dotted.

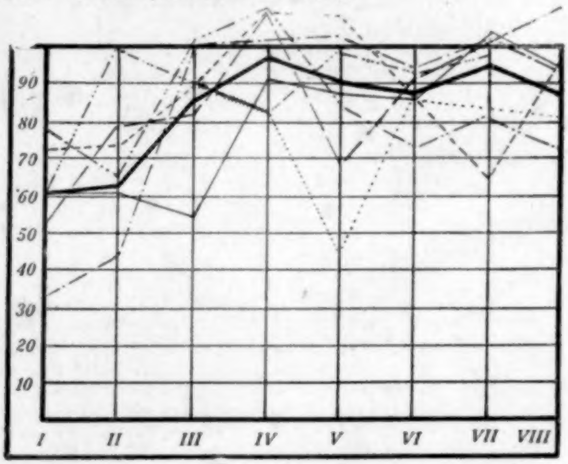


Diagram 1.

Identification. Diagram 1. Under this head were classified such questions as: "What is it?"; "What animal is that?"; "What is that thing?" It will be noticed that all these are simply requests for the name of the animal. The distribution of curves show that by far the greater number of pupils asked this question. On most of the papers this type of question was the first asked.

*It will be noted that this curve ends in the seventh grade in each graph.
**This curve begins in the third grade in each graph.

Classification. Diagram 2. Classification is somewhat related to but differs from identification in that it refers to a grouping of like things rather than to a mere name. Such questions as: "Is it a kind of crocodile?"; "What kind of an animal is it, I mean to what group does it belong?"; "Is it any relation to a frog?" were considered as an indication of interest in classifica-

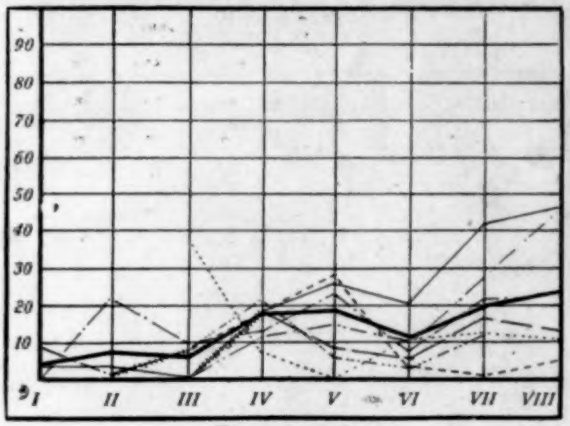


DIAGRAM 2.

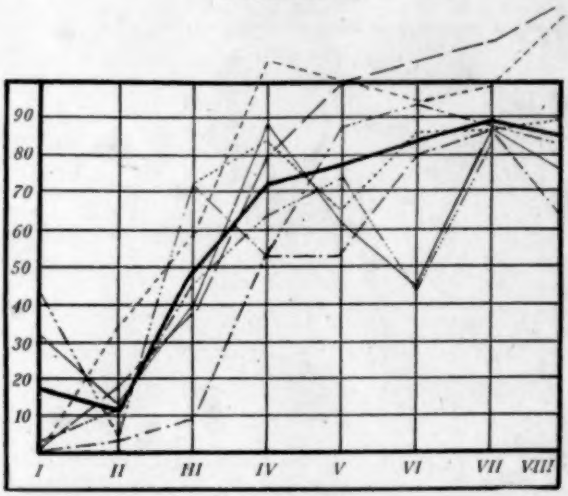


DIAGRAM 3.

tion. It is probable that very few pupils were interested in getting its classification from a strict viewpoint of evolutionary sequence but merely to learn its, "grouping with known animals," According to a distribution of the questions but little interest is manifest in this phase below the fourth grade, and only a slight interest in those above.

Environment. Diagram 3. The numbers of questions asked which were taken as an indication of an interest in the place in which the animal lived amounted to less than a fifth of the pupils in grades one and two, three-fourths of the number of pupils in the third grade, and in all the other grades a still larger number. A few type questions are: "Is it found in a lake?"; "Where does it live?"; "Does it live in the water?"

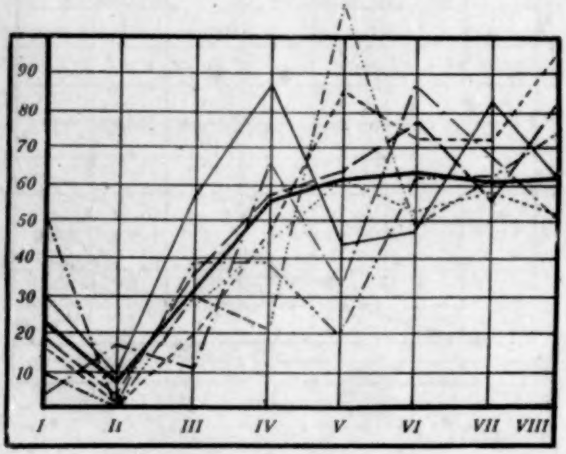


DIAGRAM 4.

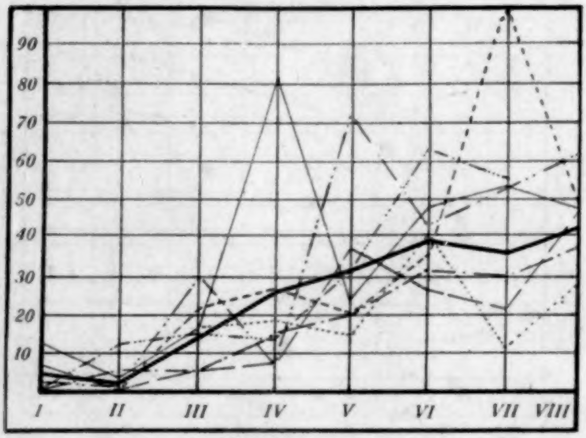


DIAGRAM 5.

Food. Diagram 4. Under this head were classed such questions as pertained to the kind of food eaten by the animal and to the manner of obtaining it. Here again the trend shows little manifested interest in the lower grades, much in the upper with little variation in grades four to eight. By noting the grouping

of the questions on some of the papers it was found that there might be two types of interest pertaining to food, one signifying a desire of owning the animal as a pet and wanting to know what to feed it, the other signifying a probable economic interest as might be involved in the question, "Does it eat fish?"

Life History. Diagram 5. "Does it have any babies?" "Does it lay eggs?" "Does it ever turn into anything else?"

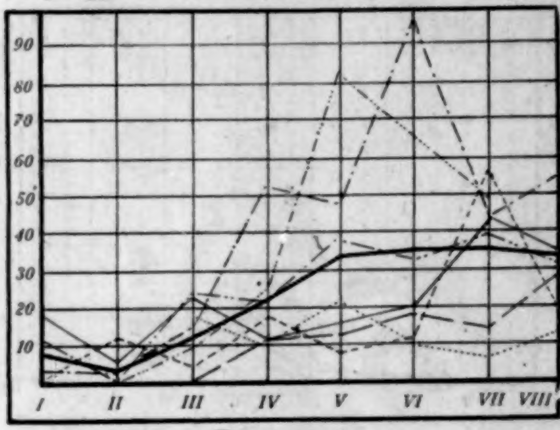


DIAGRAM 6.

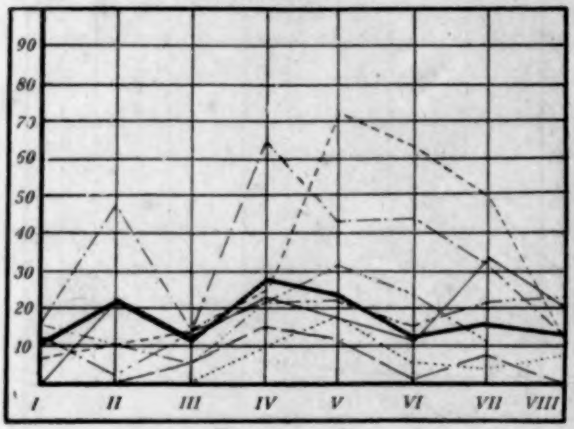


DIAGRAM 7.

Such questions as these were considered as signifying an interest in the life history of the animal. Here, too, there is an indication of a rise in interest in the upper grades. It will be seen that the fourth grade in the University Elementary School, the fifth grade in the Oak Park school, and the seventh grades in the rural schools manifested striking interest in this phase. The fourth grade had just finished a series of lessons on the life his-

tories and habits of spiders and it is possible that this fact may have had much influence on that curve.

Adaptations. Diagram 6. Questions such as: "Can it live on land as well as in the water?"; "Must it live only in the water?"; "Will hot weather hurt it?" were considered as indicating an interest in the above phase. The graph shows an increase in interest in the successive grades.

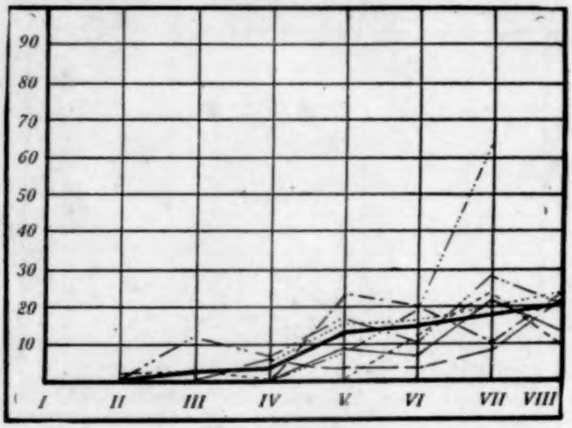


DIAGRAM 8.

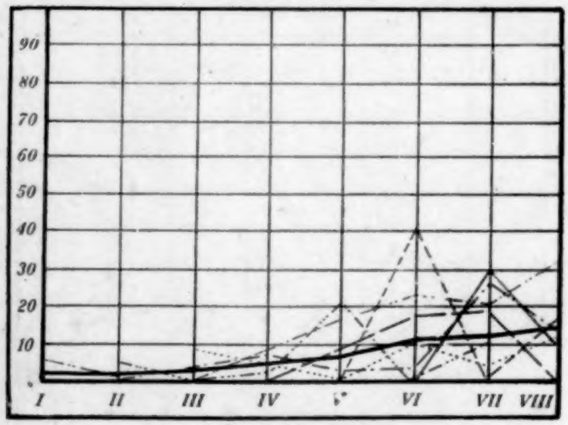


DIAGRAM 9.

Movements. Diagram 7. With the exception of the ward school in Chicago and the rural schools not many questions pertaining to the movements were asked. Grades four and five show most interest in it.

Geographical Distribution. Diagram 8. "In what countries is it found?" Does it live anywhere outside of the United States?" Such questions were classified as indicated. Not a

single question of this kind was asked in the first grade and but very few in the second. Not till the fifth grade is reached did the number of such questions asked equal more than five per cent of the number of the pupils in the class. From the fifth grade there was a manifest increase in interest in the phase to the eighth grade where the central tendency line reaches twenty-one per cent.

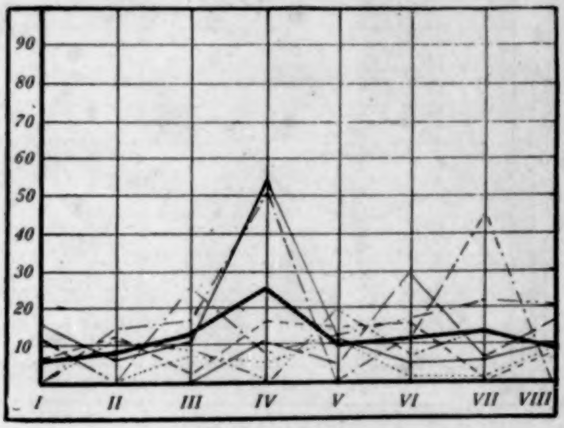


DIAGRAM 10.

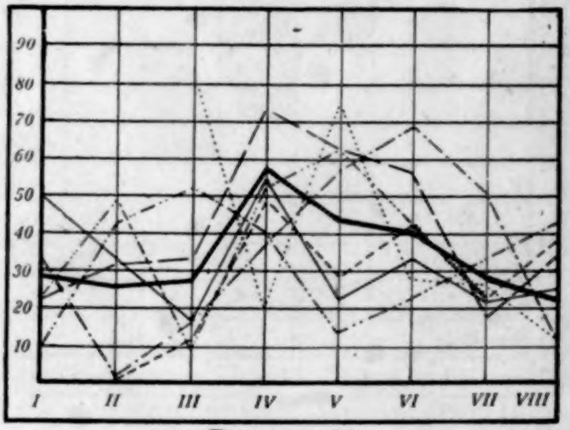


DIAGRAM 11.

Use. Diagram 9. Under this head were classed such questions as, "Is it of any use to man?"; "Is it good to eat?"; Does its skin make good leather?"; "What is its value?" These questions pertain definitely to an economic interest in the animal. The graph very closely approximates the one above.

The graphs pertaining to environment, food, life history, adaptations, classification, geographical distribution, and use agree in showing a designated increase in interest in the successive grades. It should be noted, however, that there is a lowering of the graph in the order mentioned above. The curves of distribution are high in the "Environment" graph but very low in the "Use" graph.

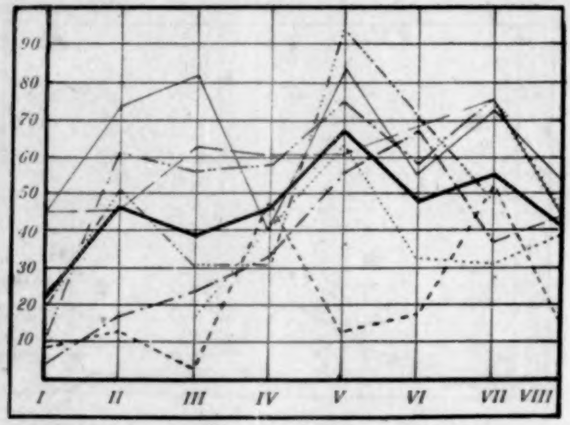


DIAGRAM 12.

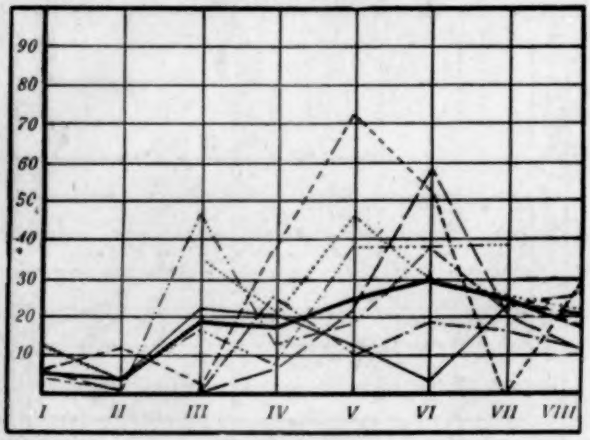


DIAGRAM 13.

Habits. Diagram 10. Under this caption were classed such questions as, "What are his habits?"; "How does he build his home?" As the skew in of the central tendency curve in the fourth grade is due to the large number of questions asked in two schools the interest manifested in this phase shows little variation throughout the grades.

Structure. Diagram 11. All questions pertaining to the various structures of the animal save those concerning the gills were graphed with the result shown in the diagram. The fourth, fifth, and sixth grades showed most interest in this phase.

Gills. Diagram 12. The gills of the animal are so bizarre and so conspicuous that, although definitely "Structures," they were classified separately. They might well have been labelled,

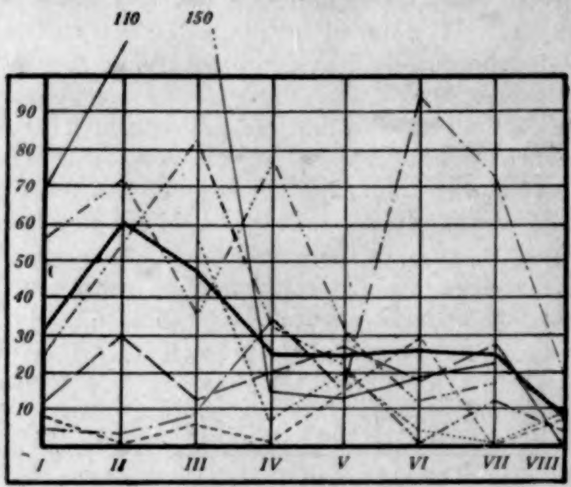


DIAGRAM 14

"Exceedingly Striking Structures" or "Extraordinary Structures." The pupils in the first four grades did not seem to recognize them as extraordinary.

Questions pertaining to function of parts, enemies, abundance, sex color, and evolution were few and the distributions of them failed to show differentiation from which definite conclusions might be drawn.

Dangerousness. Diagram 13. It has been stated that the first reaction of a city boy to an unknown animal is to find out if the animal is dangerous and immediately lay plans to get rid of it. All the children concerned in this report save those in the rural schools mentioned above are city children and a perusal of the graph will show that the contention stated above is not here substantiated. It would have been interesting to have tabulated the questions of the teachers regarding this point. Teachers as a rule were the ones demonstrating fear, not the children. Only twice in all the grades in all the schools did a grade have a number of questions as large as half the number of pupils in the class.

In the first grade of the University Elementary School during the discussion one of the girls asked if the animal would bite. She was told that it would not. On this occasion the animal was still in the room and the writer inadvertently reached down and stroked the animal. Immediately her hand went up again and she asked if she might not come up and touch the animal. The teacher reluctantly gave the desired permission and before the girl could reach the aquarium a boy had asked permission to do the same. The rest of the pupils did not wait to get permission but came in a group and crowded around the jar trying to touch and pick up the animal. The teacher was much surprised to see the children eager to touch an animal which caused her to shudder when she first looked at it. One little boy insisted on returning to the aquarium after the teacher had told the pupils to take their seats. He remarked, "I only got to touch it and I want to pick it up." In the fourth grade of one school a pupil asked if she might touch the animal. She was told that she might do as she wished. She and a few others in that grade were seen to touch it. A perusal of the graph seems to show that fear of animals is a thing taught the pupils as it is more manifest in the successive grades.

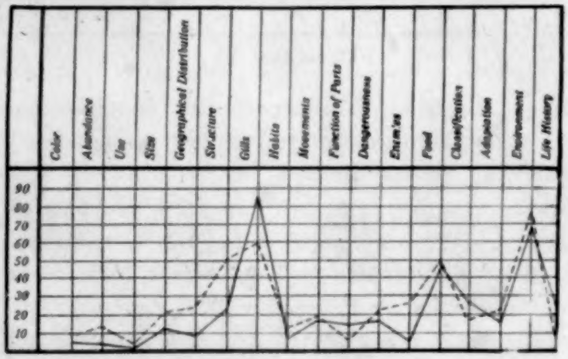


DIAGRAM 15.

Teleological Questions. Diagram 14. Under this head were classed such questions as, "Why has he such a flat head?"; "Why is his tail so long?"; "What has he four feet for?"; "Why are his eyes so small?"; "What makes it have such funny little feet?" It will be noticed that from a scientific viewpoint these questions are unanswerable. No one knows, for example, why the mud-puppy has such a flat head any more than he knows why we have four fingers and a thumb. As compared to most animals

the head is flat but as long as there have been any records available on the species the head has been flat and so far as is known no one has ever discovered why. One second grade teacher suggested that the questions were in reality interjections as, "What a flat head!"; "What funny little feet!"; and so on. This same teacher consistently confused function of structures with reasons for their existence. The curve shows a very definite falling off of interest in the upper grades in seeking "reasons" for structural characteristics.

A Check on the Experiment.

In order to get some data which might serve as a check on this experiment another exercise was planned. The pupils in the fourth, fifth, sixth, seventh, and eighth grades of The University

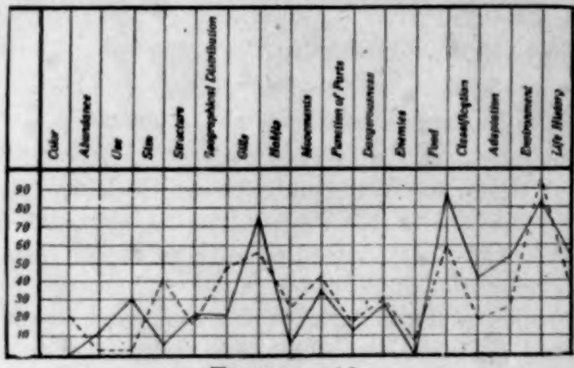


DIAGRAM 16.

Elementary School were requested to write a composition on the mud-puppy just forty days after they had had the discussion on it. In the discussion all phases of interests manifested in the animal had received consideration, hence the pupils were exposed at least to facts concerning the animal. During the forty-day intermission no further work was given them on the animal. Neither pupils nor teachers knew that the written work was to be called for. As in the first experiment no questions or suggestions were permitted and no words were spelled for them the object being as in the original experiment that no suggestions be made which would stimulate added ideas to other pupils. In tabulating the results one count was given for each phase mentioned, regardless of the space given the phase in the discussion. It will be seen that this differs from the former tabulation in which each question was weighted thus making it possible for a single phase to receive more than one count. In many of the papers there was irrelevant material which was not tabulated.

In the diagrams used to show the results of the tabulation dashed lines are used to indicate the distribution of the compositions, a continuous line, the questions asked in the original experiment. The horizontal lines indicate percentages, the vertical lines, phases of interest.

Because of similarity of results the graphs of the fifth and seventh grades will be shown, the rest omitted. In all the grades there was a remarkable similarity in the lines representing the compositions and the questions. The data seem to substantiate the idea that the pupils wrote about the phases on which they asked questions. The check thus supports the contention that in this experiment the children's questions are indicative of their interests.

II. Pupils' Interests in Plants, Animals, and Physical Phenomena.

Purpose and Plan of the Work.

The purpose of this experiment was to gather data relating to children's interests in the three phases of elementary science mentioned above. As in the preceding one the work was done in regular school hours, the plan being to give a class exercise in which each phase should be presented, each receiving as nearly as possible an equal amount of time and equally stressed in the presentation. At the close of the exercise a typewritten set of instructions concerning the further procedure were given the teacher. On the following school day the regular teacher was requested to call for a written exercise restricting the pupils to write on one phase only.

There are many possible sources of error in an experiment of this type. In the first place it is not argued that the three phases chosen are of equal moment. Lacking proper standards of measurement we cannot say that each phase received a like amount of stress in the presentation. Perhaps the pupils in one school might be particularly interested in one phase because they had been learning much about it in their regular class work. The converse of this might equally well be true, namely that they were most interested in a phase because it had been omitted from their regular classroom work. Both these arguments were given repeatedly by teachers who participated in the work. However, it must be remembered that careful effort was constantly made to keep the three parts of the experiment well balanced and to give equal amount of stress to the presentation of each.

It was planned to choose for presentation things which would be new or novel to most of the pupils. To represent the animals, a bird commonly known as the black-skimmer or scissors-bill was chosen. For the plant, a species of Bryophyllum commonly known as the life-plant was used while the pendulum represented the physical phenomena. These three things were presented in each exercise, eight to ten minutes being given each thus making the exercise of twenty-four minutes to a half hour's duration.

Subject Matter and Method of Presentation.

The bird. A mounted specimen of the black-skimmer was used. The class was told approximately the following: "The name of this bird is black-skimmer, (the words, "black-skimmer" were then written on the board). It gets its name from the color of its back, which you see is black, and from its habit of skimming over the water. It is an ocean bird and may be found on the Atlantic coast from Virginia southward and on the coast of the Gulf of Mexico. Notice the peculiar structure of the bill." They were then shown the remarkable bill of the bird, the two mandibles of which are very long and so thin that if a finger be held behind them in a bright light the outline of the finger can be easily seen. The lower mandible in the specimen used was about half an inch longer than the upper one. After the class had noted these things the pupils were told that, knowing the bird to be a water bird and knowing the peculiar structure of the bill and the bird's habit of skimming over the water, they should be able to guess what the bird eats and how it gets the food. That the bird fed on fish was usually guessed at once. many guesses were required, however, before the correct manner of procuring the food was mentioned. The guesses usually given were, that the bird would pounce down in the water and capture its food as does the kingfisher, that it used its sharp bill as a spear and pierced the fish, that it would use its sharp bills as a pair of scissors cutting the fish in two and later picking the pieces up and eating them, that it would catch the fish in its claws, carry the prey to the shore and eat it. In each exercise the correct method was guessed. The bird "skims" the surface with its lower mandible cutting the water. With its bill so placed it can scoop up minnows and small fish which swim at the surface.

The plant. In presenting the life-plant two living potted specimens were used, one a mature plant more than a foot high and the other a leaf which had been so planted that half of it pro-

truded above the soil and which had given rise to two small shoots bearing six leaves each. They were told that the life-plant grew in Mexico and that its name was life-plant (like in the preceding the name "life-plant" was written on the board). They were given as possible reasons for its name the fact that new plants could be grown from it by putting either its shoots or leaves in the ground. Before telling them this, however, they were asked to state as many ways as they could in which new plants might be secured from other plants. The following suggestions were usually given; by means of seeds, stem cuttings or slips, bulbs, tubers, grafts, underground roots, and underground stems. Following this they were shown the pot containing the leaf from which were growing the two new shoots. It was explained to them that very few plants would produce new ones in this way.

The pendulum. For this part of the experiment a rough piece of apparatus was constructed. For the base a board twelve by sixteen inches was used. To this base was nailed a sixteen-inch upright to which was fastened an arm projecting above the base and parallel to it. Through the free end of this arm was drilled a small hole in which a string might be raised and lowered and be held at any desired length by a wooden peg. A string to the lower end of which was fastened a small iron drawer pull constituted the pendulum. The pupils were told that this part of the exercise dealt with the pendulum and were told that the pendulum was the string with the iron weight that the rest of the apparatus was merely a support for the pendulum. As with the other two things the word, "pendulum," was written on the board. The following things were demonstrated, the pupils observing and doing the counting: That when once started the pendulum continued to go in the same direction, (plane); that with a given length of string the pendulum makes the same number of movements whether it goes through much space or little space, whether it goes in one plane or in a circle; that the shorter the string the more movements and the longer the string the less movements. Using the knowledge they had gained they were asked to guess the length of string required to make a pendulum which would make one swing in a second.

It will be seen that in each of the above exercises the pupils in the class participated.

School Types Used.

Three of the schools in which this experiment was tried were

mentioned in the succeeding discussion, namely, The University Elementary School, the Gary school, and the Oak Park school. In addition to these there were two others.

Canton, Illinois. Canton is a small, manufacturing town in Illinois. It has a large per cent of foreign-born children in its schools. It had an excellently administered system with an exceptionally efficient corps of teachers. At the time the experiment was given, there was no definitely organized course of study in elementary science work but the subject was taught in all grades.

Training School of The Western Illinois State Normal School, Macomb, Illinois. The Supervisor of Teacher Training and most of the grade teachers in this school were intensely interested in elementary science and at the time of the experiment were engaged in formulating a course of study in it.

The grades concerned and the numbers of pupils in each are shown in the following table:

Schools, Grades, and Pupils Involved.

	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Total
U. E. S.	....	39	40	30	25	....	134
Gary	49	33	18	18	68	....	186
Oak Park	30	32	32	21	50	36	201
Canton	....	41	42	42	61	22	208
Macomb	....	18	20	20	20	20	98
Total	79	163	152	131	224	78	827

At the conclusion of the exercise the teacher in charge was given typewritten instructions as follows:

"On (name of day) ...., will you please have a short, written exercise on this lesson.

"Have the pupils write only on one of the things presented, that is the plant, the animal, or the pendulum.

"In order that the pupil may have the three phases of the work in mind will you please write the following words on the board in this order:

....

....

....

"Be sure that the pupils' names and grades are on the papers.

"Do not let the pupils know before the time of the written exercise that they are to do this.

Tabulation of the Results.

The thing on which each pupil wrote was taken as indicative of the one most interesting to that pupil. In the following table

the numbers given are the nearest whole per cent of pupils writing on that phase.

	U. E. S.	Gary	Oak Park	Canton	Macomb
Third Grade					
Plant	....	20	30	....	....
Bird	....	66	37	....	....
Pendulum	....	14	33	....	....
Fourth Grade					
Plant	20	43	26	8	28
Bird	20	49	71	84	55
Pendulum	60	8	3	8	17
Fifth Grade					
Plant	12	46	22	12	20
Bird	68	36	51	81	60
Pendulum	20	18	27	7	20
Sixth Grade					
Plant	23	41	13	33	15
Bird	54	39	80	62	70
Pendulum	23	20	7	5	15
Seventh Grade					
Plant	32	27	6	11	30
Bird	52	57	64	89	55
Pendulum	16	16	30	0	15
Eighth Grade					
Plant	....	....	3	14	35
Bird	....	....	84	81	60
Pendulum	....	....	13	5	5

A perusal of the table shows that in twenty-two of the twenty-five classes listed the bird was the thing receiving most compositions by the pupils. The plant received most consideration in the fourth and fifth grades of the Gary school and the pendulum in the fourth grade of the University Elementary School. In the normal school at Macomb an additional check was given to see if additional evidence of interests might be secured. You will notice that in this school the bird fared best in each grade. Just two weeks after the exercises had been given the following request was made to the pupils "If Mr. Finley were to come to us today and discuss just one of the things he demonstrated to us two weeks ago which would you prefer? Write your choice on these slips of paper." The result:

	Fourth	Fifth	Sixth	Seventh	Eighth
Plant	0	10	30	5	15
Bird	89	75	65	75	60
Pendulum	11	15	5	20	25

Some of the written comments of teachers concerning the work and made at the time the exercises were given to their classes are interesting.

Fourth Grade, University Elementary School:
Teacher—"The class was most interested in the bird. Interest rather low when plant was introduced, so many new facts having been brought before the minds of the class."

Assistant—"Beyond doubt the class was most interested in and most will write about the plant." Refer to the table to see what actually happened.

Fifth Grade, University Elementary School:

Teacher—"The pupils were most interested in the bird; they had studied it last year."

Fifth Grade, Macomb:

Teacher—"More interest in the pendulum."

Sixth Grade, U. E. S.:

Teacher—"Interested most in plant, second in pendulum."

Sixth Grade, Macomb:

Teacher—"Interest equal in pendulum and plant and greater in bird." An excellent guess.

Seventh Grade, U. E. S.:

Teacher—"Most questions were asked about the plant. Interest about same in all, possibly a little more in pendulum for they counted."

Effect of Order in Presentation on the Pupils' Responses.

In all save the University Elementary School the things were presented in the class exercises in the order shown in the following table.

	Third	Fourth	Fifth	Sixth	Seventh	Eighth
Plant	2	1	2	3	2	1
Bird	3	2	3	1	3	2
Pendulum	1	3	1	2	1	3

Inasmuch as the bird received most consideration in each grade the order in which the phases were given in the class demonstrations showed no effect on the pupils' responses.

Effect of Order of Suggestion on Pupils' Responses.

The "order of suggestion" refers to the order in which the names were written on the board. With the exception of the school mentioned above such order was as follows:

	Third	Fourth	Fifth	Sixth	Seventh	Eighth
Plant	1	3	1	2	1	3
Bird	2	1	2	3	2	1
Pendulum	3	2	3	1	3	2

For the same reason as mentioned above the order of suggestion showed no effect on the responses.

Comparison of Responses of Boys and Girls.

In the University Elementary School and the Gary School the boys' and girls' papers were tabulated separately with the result shown below. The numbers given indicate nearest whole per cent.

University Elementary School:

	Fourth		Fifth		Sixth		Seventh	
	B.	G.	B.	G.	B.	G.	B.	G.
Plant	13	25	11	14	21	25	27	40
Bird	27	17	58	76	43	62	53	50
Pendulum	60	58	31	10	36	13	20	10

Gary School:

	Third B.	Third G.	Fourth B.	Fourth G.	Fifth B.	Fifth G.	Sixth B.	Sixth G.	Seventh B.	Seventh G.
Plant	14	27	36	50	52	40	26	55	27	27
Bird	58	73	64	34	42	30	43	36	50	63
Pendulum	28	0	0	16	6	30	31	9	23	10

In seven of the nine classes listed above the boys and girls agreed in giving most of their compositions to the same thing. You will recall that there were three classes in the whole twenty-five in which the bird failed to get most consideration. Two of these classes, the fourth grade in the first table and the fifth in the second, find both boys and girls in agreement in giving a preponderance to another phase.

In presenting this article the writer does not do it with the idea that it has in it startling and hitherto unknown facts but more with the hope that it will stimulate quantitative investigations in the teaching of elementary and secondary sciences.

INTERSTATE TOWNS.

There is an old story that many of the names of towns, sleeping cars, etc. were devised by a maniac who had a passion for writing letters on the walls of his cell in meaningless combinations. Travelers who attempt to pronounce some of the difficult names they see on cars are very much inclined to believe this story.

The appropriate names for new towns are often as hard to select as car names and some of those selected are apparently as meaningless and are as difficult to pronounce. For many of them, however, there is a reason. Many towns that lie partly in one State and partly in another, or close to the State line, have fine sounding and distinctive names that are made up of parts of the names of the two States. The following are names of this kind that appear on maps issued by the United States Geological Survey of the Department of the Interior:

Arizmo, Arizona-New Mexico.
Calada, California-Nevada
Calexico, California-Mexico.
(In the Mexican half of the town the order is reversed and it is called Mexicali.)
Calneva, California-Nevada.
Calvada, California-Nevada.
Calzona, California-Arizona.
Colmex, Colorado-New Mexico.
Coluta, Colorado-Utah.
Delmar, Delaware-Maryland.
Kanorado, Kansas-Colorado.
Kenova, Kentucky-Ohio-West Virginia.
Mondak, Montana-North Dakota
Monida, Montana-Idaho.
Penmar, Pennsylvania-Maryland
Sylmar, Pennsylvania-Maryland.
Texarkana, Texas-Arkansas.
Texico, Texas-New Mexico.
Texla, Texas-Louisiana.
Uvada, Utah-Nevada.
Virgilina, Virginia-North Carolina
Wyocolo, Wyoming-Colorado.

In Texarkana, which is one of the largest towns on the list, the post office building is on the boundary line, one half in each State. Some other names of this class not yet shown on Geological Survey maps are Alaga, Arkinda, Arkla, Dakoming, Texhoma, Urado, Wissota, and Wyuta.

It will be noted that this idea of combination appears to be particularly a southern and western one. North of Mason and Dixon's Line and east of the Mississippi it has not prevailed.—[*U. S. Geol. Survey.*

MINIMUM HIGH SCHOOL MATHEMATICS.

By Florian Cajori,

University of California, Berkeley.

A pupil permitted to graduate from a high school without any mathematics is in danger of remaining the unenvied occupant of a blind alley. The attempt to reduce the minimum high school course in mathematics to one year is unwise, because thus far experience shows that one year is too short a time for a pupil to acquire a knowledge of elementary mathematics that can be applied in practical life. Two years would seem to be a better minimum.

This declaration is based on the proposition that *there is no subject taught in a high school, except English, which makes as frequent and general contact with practical life as does elementary mathematics (arithmetic, elementary algebra and geometry).* This proposition cannot be proved with mathematical rigor. It is a statistical question for which precise data are wanting. Nor is it claimed that every high school graduate does make direct use of all his elementary mathematics. Our claim is simply this, that elementary mathematics, properly taught, in which much of the mechanical work in algebra is replaced with practical applications, and self-evident propositions and incommensurable cases in geometry are touched upon only very lightly, in which there is a certain degree of fusion of mathematical subjects, in which teaching material is drawn largely from the world of work, in which principles are applied to the conditions and problems which are encountered in the industries—mathematics thus taught, I say, can be used more often in the life of today than any other high school subject, except English.

In this paper we disregard culture and mental training; we consider only practical applications. If it be argued that the average citizen has but little need of mathematical facts beyond the elements of arithmetic, then attention must be called to the truth, that the same remark applies in a much greater degree to every high school subject, except English. That Columbus discovered America in 1492, that Newton's law of gravitation is so and so, that the chemical formula for water is H_2O, that Thomas Jefferson was once President of the United States, etc., are matters of no direct use in his daily occupation. However, the average citizen in his every-day transactions does make direct use of his arithmetic. If he is building a home or a fence, or is putting in a cement walk or placing new furniture

in his office, or determining the least space that will answer for his garage, or is estimating distances between two places on a map, he is drawing upon his knowledge of elementary geometry. Possibly he had occasion recently to draw upon his knowledge of algebra in order to understand the graphs printed in the New York Tribune and the Literary Digest for November 29, 1919—graphs exhibiting the trend of prices of industrial stocks and railroad stocks on the New York market for 1917, 1918, 1919. Our proposition is true; no other high school subject, except English, is used as generally by the ordinary citizen.

In a machine-shop school, as suggested by the Federal Board for Vocational Education (Bulletin No. 1, 1917, p. 43), "if three hours a day are given to shop-work, a part of the remaining time might be given to such topics as machine-shop mathematics, drawing as related to machine-shop trades, science applied to the machine shops, and the hygiene of the trade."

In another place (Vocational Rehabilitation Series No. 25, 1919, pp. 5, 7) the Federal Board says: "Many draftsmen with the equivalent of only a common school education have been able by application and attention to business to advance themselves very satisfactorily. On the other hand, the equivalent of a high school education with an elementary knowledge of algebra, trigonometry, mechanics, heat and other scientific subjects involved, is of very material benefit."

In a third article (Vocational Rehabilitation No. 28, 1919, p. 5) the Federal Board says: "A high-school education would help you very much in office work and in the shop trades. If you can read drawings and blue prints, you can easily learn to read the special sort of blue prints that are used in navy-yard work, and this will enable you to shorten your training school. A knowledge of geometry will help you very much in a number of shop trades, such as sheet-metal work and mold-loft work. If you know how to make mechanical drawings you can greatly shorten your training time for work in drafting rooms. The more mathematics and drawing you know, the better your chance of securing promotion to some form of supervisory work." By mentioning mathematics, to the exclusion of other topics of high school study, the Federal Board assigns mathematics a central position in provocational education for the trades.

As to scientific farming, I quote again from the Federal Board (Vocational Rehabilitation No. 21, 1919, p. 11): "Your knowl-

edge of common school branches, especially English, mathematics and current literature, will greatly assist you in studying the elementary principles of chemistry, etc." "What is worth getting requires time and effort in this as well as in other things." Is it not worthy of our attention that the Federal Board for Vocational Education should single out English and mathematics as the two prevocational topics needing particular emphasis?

In deciding that girls should not be required to study elementary mathematics in a high school, harm is done to girls who are inclined to follow the path of least resistance and to forego mathematics. An efficient woman needs mathematics as much as a man, especially at this time when she is reaching out into new vocations, at this time when it is realized that house-keeping can and should be made much more scientific and efficient.

Arithmetic is of importance in such of her commercial occupations as retail selling. Accuracy and speed in addition, subtraction, multiplication, fractions and percentage, discounts, are all-important. Who will deny that drill in algebra accustoms girls to greater accuracy in arithmetic and gives them a general intellectual grasp of arithmetical work that adds to their efficiency? Who will deny that elementary geometry enables one engaged in retail selling to understand more readily graphic charts exhibiting commercial data or assists one in making sales of wire goods, lumber, wall-paper, yard goods of different widths? Except the correct use of the English language, no factor enters as prominently in retail selling as does a ready knowledge of elementary mathematics.

As a home-maker, woman needs mathematics pre-eminently. The mother bird in the nest on the tree needs no mathematics; she builds her nest by instinct and does not study market prices. The efficient human mother has a more complex task. As a purchasing agent, she ought to prepare a budget for the family and keep household accounts. In this task no other high school subject helps her as much as does mathematics. It is desirable that she be familiar with drawing and design as applied to clothing and know how to allow, in her measurements, for tucks, hems and ruffles. "Bias ruffles," we are told, involve new geometrical difficulties, the finding of the diagonals of squares. In planning a home she ought not to be blindly dependent upon an architect, but through her knowledge of geometry, be able intelligently to interpret the architect's drawings—the floor plans, the front

and side elevations. Through her knowledge of drawing to scale she can judge for herself whether a certain design of rooms will be satisfactory to her or not. She should be able to figure out the relative costs of furnishing, to verify the gas and electric bills by reading the meters herself.

A committee of scientific experts is being organized by the National Research Council to study the most effective grouping and preparation of foods (see *Science*, Dec. 7, 1919). Such a committee is useless, unless the housekeeper possesses the mathematical and scientific knowledge intelligently to apply the results of their investigations. Questions of "balanced rations" must receive greater attention, if physical vigor is to be improved. Food-tables, like the one issued by the American School of Home Economics, have received little attention, because of the disinclination of housekeepers to do the computing.

We have touched the leading occupations of men and women who by their high school training may reasonably group themselves in the class above that of the ordinary unskilled laborer. We have followed them into their homes, shops, stores and farmyards. If our description of conditions is at all faithful to life, then their occupations for the earning of their daily bread invoke the aid of elementary mathematics more than that of any other high school study, except English.

SCHOOL GEOGRAPHY MAPS MISLEADING.

It has long been the dream of geographers to make a series of maps of the world on a uniform scale. Indeed, it is considered unfortunate for school children that the geographies do not show all countries by maps on a single, uniform scale, for unless a student observes very carefully the figures showing the scale of each map or the figures showing the area of the country mapped he is likely to get the impression that certain distant lands, which are generally mapped on a small scale, are smaller than those with which he is most familiar. Take Australia, for example: the maps in the geographies now used in most of our schools show it on a small scale—about one-third as large as that used for the map of the United States; yet Australia is in fact nearly as large as the United States—only about one-fortieth (2 1-2 per cent) smaller. China is generally shown smaller in area than the United States, yet it is about one-third larger.

The work of preparing maps of the entire world on a uniform scale of one to one million—that is, maps on which one unit (any unit—inch, centimeter, millimeter, etc.) represents one million like units on the ground—has been under way for several years, and the United States Geological Survey, Department of the Interior, has made considerable progress in its work on the parts of this map that were assigned to the United States. The principle used in preparing these maps, if adopted by the publishers of school books, will give the children accurate impressions of the relative sizes of the countries of the world.

THE FIRST MONTH OF GEOMETRY.

By Jos. A. Nyberg,
Hyde Park High School, Chicago.

While the many committees and associations are at work deciding what mathematics shall be taught in the high school, it may be of some value to discuss in the meantime some of our methods of teaching. The following paper is a presentation of one way of introducting geometry to the pupil. In working out this method I have assumed that the difficulties with which the pupil must ordinarily contend (taken in the order in which they occur) are:

1. The technical notation and language consisting of many new words, such as hypothesis, axioms, postulate, perpendicular, vertical (used in a sense in no way relating to the ordinary word), supplement, complement, etc.

2. The logical difficulties, or the pupil's inability to understand why much effort is expended in proving facts that appear obvious to him. Even when the pupil may understand the class discussion, he feels uncertain of himself for surely teachers would not be paid to explain such trivial matters.

3. While struggling with the new words and the apparent unreasonableness of the teacher, the pupil must also learn to present his ideas in a new way, unlike the way he is allowed to present them in an English or even an algebra class, and in a mechanical form with a reason attached to every statement.

The first difficulty is the easiest to overcome as we may proceed slowly enough to let the many polysyllabic words become meaningful. The third difficulty could be overcome by letting the pupil present his ideas in any way he choses during the first month. This will mean more work for the teacher as more time will be required to read and correct the homework; and any method involving more work for the teacher is, for that very reason, doomed to fail. The second difficulty is considered sufficiently treated by some writers if they present a page of optical illusions showing that lengths of lines must not be judged by appearances. Such illusions are a poor argument for the pupil readily answers that these illusions were made purposely to deceive, and no such purpose exists in his own drawings. Further, any attempt during the first months to make the pupil see the logical setting of the facts seems futile because this appreciation of logic is to be developed by the subject, and hence can not be assumed to exist or be used as a foundation.

The following method is therefore not based on logic but on the idea that nothing shall be introduced until the need for it has been shown.

In the first lessons I present in the standard way a few problems for whose solution a knowledge of geometry is needed such as measuring the distance from A to B on opposite sides of a lake. To visualize the problem to the pupil I draw the figure on top of a table, placing upright pencils at the points, and having pupils sight along the pencils to get them in a line. The next problem, which I use because it emphasizes angles, is that of the farmer who wishes to continue on the further side of a lake, a fence which he has started on one side. This is solved by using a rectangle, not a triangle. The third problem consists in tearing off the corners of a triangle and placing the angles about a point. We see that it is a good guess that the outer edges of the sum lie along a line. "But," I ask, "by what reasoning could you convince a blind man of that fact?" Geometry will furnish the proofs, and will determine the lengths that can not be measured.

The talk thus far has involved triangles, and our first question is "When are triangles equal?" or, better stated, "What information must we have about two triangles in order to decide whether or not they are equal?" The first guess is that they are equal if the three sides of one are equal to the three sides of the other. Evidently correct, for if I take three sticks I can make only one triangle from them. But in making the triangle, I also *simultaneously create* three angles; and how do we know that the three angles which I make will be respectively equal to the three creations of some one else? Hence, before we can discuss triangles further, we must see what we know about angles.

I. *Angles.* In considering angles the ideas to be treated are:

(a) The notation. First we name an angle by stating its vertex and its sides; then we write it as $\angle$(BA, AC), and finally contract this to $\angle$BAC. If this development of the notation is presented instead of the mere fact, the pupil can see reason for our action.

(b) The size of an angle is independent of the lengths of its sides.

(c) Equality of angles is tested by placing the vertices together, making two sides coincide, and then deciding whether the reamining two sides will or can be made to coincide.

(d) Measurement of angles. We define perpendicular lines

to be lines which meet or cross so that two adjacent angles are equal. This defines a right angle. A unit angle is defined as one ninetieth of a right angle. Here we prove (that is, explain or call attention to) that all right angles are equal, and see the necessity for proving it, namely, in order that the units used by all people may be the same.

(e) The construction for copying an angle, bisecting angles, drawing perpendiculars, postponing the proofs that our constructions are correct.

The words complement and supplement are postponed until we are ready to use them.

II. *Triangles.* We now return to triangles. There were six elements to be considered, three sides and three angles. Evidently if the six of one triangle are equal to the six of the other, the triangles are equal. This we can verify by superposition. I write on the blackboard: Place A on A′; rotate the triangle if necessary until AB lies along A′B′; B′ will fall on B because, etc. Then I ask: Did we use all of the six elements? Perhaps the triangles are equal if only five elements of each are equal, or if only four, or three. What is the minimum? We try two. Finally we decide to discuss the theorem:

Two triangles are equal if three elements of one equal three corresponding elements of the other, provided (1) at least one is a line, and (2) the three are properly selected.

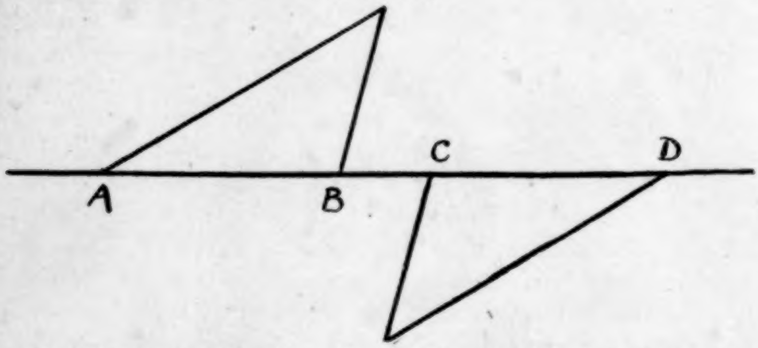
The necessity for the first provision can not, of course, be proved rigorously. We can make it look reasonable by drawing similar triangles; but an argument is not useless because it lacks rigor if the pupil recognizes that fact and sees why. An incomplete proof should always be an inducement for further study in the hope of completing the gaps. The second provision refers to two triangles having two sides and an opposite angle equal to these corresponding elements in another triangle. A single illustration is sufficient to show the necessity of the provision. (And at the beginning of the year this usually causes greater astonishment than any optical illusion.) This case nearly always introduces the question: Is it always possible to construct a triangle with any selection of sticks for sides? I also consider here the case wherein two angles and an opposite side are equal to the corresponding elements. Assuming that the sum of the angles of a triangle is 180°, we can see that this choice of elements is satisfactory. If we had a similar relation for the sum of the sides of a triangle, the second provision could

be eliminated entirely. The reader will notice that in using this assumption about the sum of the angles, I am creating additional reasons for the study of the subject.

This discussion will take several days or a week and in order to give written home work during these days, I assign construction problems dealing with angles, bisectors, perpendiculars, etc., and spend half the class period for such matters.

Finally, we are ready to prove the two standard theorems about the two sides and the included angle, and the two angles and the included side. In the statement of these theorems, the text books have abbreviated Euclid but not improved him, for the important idea is not that the two triangles are equal, but that the remaining elements are equal. In various ways I try to impress this fact on the class but the pupil seldom sees the significance of it until he has worked some exercises in which the equality of the triangles is merely a step to some more important equality.

In working the exercises based on these theorems I emphasize that the procedure will be: From some given information about lines and angles, we are to find two triangles which can be proved equal, and then in these two triangles we are to discover that certain other lines and angles are equal. The first exercises should not say, for example: Prove EF = GH, or prove $\angle 1 = \angle 2$, but should read: If we know that AB = AC, $\angle 1 = \angle 2$, $\angle 3 = \angle 4$, what other lines and angles can we discover to be equal? The pupil when writing the exercise labels one part "Given Information" and finishes with "Discoveries."



III. *The Given Information.* The making of discoveries would be easy if our information always referred directly to the six elements of the triangle. But in most cases the information is camouflaged, or concealed in a forest of apparently

irrelevant ideas. Since it is always so in real life, why should we expect it otherwise in geometry? An illustration will show how this arises. If we are told that AC = BD, we can not use this information because neither AC nor BD are sides of the two triangles. The subtraction of BC from each line gives us the desired information AB = CD.

Hence, the necessity having arisen, it is at this stage of the work that we begin the study of five axioms which allow us to add, subtract, multiply, divide and equate lines or angles. In the practice on the use of the axioms, the pupil's state of mind should be that of trying to make new equations from old ones, using his five tools. One of the parlor games of long ago was that of seeing who could make the most words out of the letters from some long given word. The pupil should see that he is playing the same kind of a game. Illustrations from algebra, exercises on areas, volumes, weights, etc., should be used as well as lines and angles. The words complement and supplement are not yet introduced in order that all the emphasis may fall on the axioms and that all results may be written as equations.

IV. *The Discoveries.* The pupil's attitude should now be that of a detective unraveling a mystery for which he has been furnished a few clews. He is seeking new relations between angles and lines; but during the first month we should not expect to see the relative importance of his various discoveries. That the equality of one pair of lines is more important than some other equality is decided by the future uses to which we can put the equality. Hence, whenever triangles are proved equal, the pupil may as well write down all of his new discoveries or equations.

Thus, in that fundamental proposition in which the vertex angle of an isosceles triangle is bisected (if ABC is the triangle, AB = BC, and BD is the bisector of the angle B) the pupil makes three discoveries: AD = DB, $\angle$ADB = $\angle$CDB, $\angle$A = $\angle$C. These he next translates into English: (1) The bisector of the vertex angle of an isosceles triangle bisects the base. (2) The bisector of the vertex angle of an isosceles triangle is perpendicular to the base. (3) The base angles of an isosceles triangle are equal. Here all the discoveries are worth remembering—a thing which will not be true in every exercise. Later, but not now, we can expect the pupil to judge the relative values of the discoveries.

The above theorem is one which can profitably be studied for a long time as it is useful in making the pupil see that the

object of geometry is to draw conclusions from given facts. Write, for example, on the blackboard the six equations between the twelve elements of the two triangles: AB = BC, AD = DB, ... $\angle A = \angle C$, and ask: Given any five of these equations, can I always prove the sixth? Given any four, can I prove the remaining two? Given any three, can I prove the other three? Given any two, etc.[1] The pupil is also required to state each exercise in English: thus, if he chooses to use AD = DB and AB = CB from which to prove the remaining four, he says: If the midpoint of the base of an isosceles triangle is joined to the vertex, then etc. This enables us to introduce the word *median* not to give the pupil one more word to memorize, but because the word is useful in simplifying our language. In fact, only after the pupil has stumbled through several circumlocutory phrases do I introduce him to a word like *midpoint.*

V. *The Presentation.* Nothing has been said in the class so far about the manner of presenting a proof. The proofs of the fundamental theorems are written in paragraphs and the directions in any construction problem are written in paragraphs; much as the pupil might write an exposition for his English class on how to erect a tent when camping or how to bake a sponge cake. But now that the pupil has solved the mystery he is no longer a detective; to shift the metaphor and use terms from the commercial world, he is now a salesman trying to sell his idea to a skeptical customer; and just as a salesman is not sent out on the road to sell goods until he has become acquainted with them by experience in the stockroom, so the pupil should not be expected to present a standard proof until the various theorems have become a part of his knowledge. We are now ready to introduce words like hypothesis and congruent and for the first time we write a proof with one column for statements and another for reasons. The pupil may wonder why we did not do the same thing in studying algebra the previous year. I have myself asked the same question of many teachers and the answers are so various that I wonder if we have analyzed the question carefully. My own answer, in part, is that in algebra we deal with a very few fundamental and simple operations; in geometry a theorem is frequently a statement of a result obtained from many complex operations which we do not wish

[1]And if the class is a bright one, discuss: How many exercises are involved in such a discussion? And why does the third of the three conclusions in the above theorem omit the words "bisector of the vertex angle?" And can it be proved without drawing BD?

to repeat in detail on every occasion that we use the result, and our column of reasons is a summary or reminder of these details. Algebra is the hammer and saw and screw driver of our tool chest; geometry is a collection of machines which swallow some boards and nails at one end and turn out a finished article of furniture at the other end.

The numbering of all the steps of a proof is discouraged as they are not all of equal importance. Some steps are written with further indentations from the margin than other steps (particularly when lines or angles are added, subtracted or equated to find some more important equality) such as we see in briefs for a debate. Important steps are labeled 1, 2, 3, and the three steps which are always necessary to prove triangles congruent are labeled 1, 2, 3.

The analysis of an exercise is a test of the pupils' logical abilities, and the presentation is or should be a test only of his good judgment in presenting facts; but have we fully realized how a study of the presentation can be used as a means of introducing some of the theorems and words which are so frequently merely thrust upon the pupil? The pupil can be taught to see that, like a salesman, his presentation can be improved by an increase of his vocabulary. The words complement and supplement are introduced at this point for the same reason that words like *median* and *midpoint* were introduced above. Similarly many subordinate equations are eliminated when we introduce the corollary, "if two angles of a triangle were equal, the third angles are equal." Many theorems exist merely to shorten the proof of some future theorem. Nothing illustrates this better than to have some exercise proved without using certain theorems and words and then rewritten, using the theorems. The resulting simplicity of our presentations is the reason for the existence of many theorems. But how often do we call attention to that simple fact? If the beginnnings of the subject appear ridiculous to the pupil, isn't it because we have shown him too many details without showing the why and wherefore of the details? The writer seldom assigns a theorem without first studying with the class some exercise for whose solution the theorem is of value in shortening the presentation. The exercises are not put in the text to illustrate the theorems; the theorems are inserted to help solve the exercises.

To summarize, this introduction to geometry is based on the following principle: Instead of making the subject strictly

logical from the beginning, let us first acquaint the pupil with the subject matter, then develop his reasoning abilities without too much emphasis on how he presents his facts paying due attention, of course, to his grammar and English) and last, when he is ready to present his results let us begin to emphasize the details.

A MINERAL ALMANAC.

A preliminary summary of the mineral production of the United States in 1919 has just been issued by the United States Geological Survey, Department of the Interior. This pamphlet, which consists of 128 pages, shows in compact form the output and value of about 70 minerals. Many of the figures are necessarily estimates, but the cooperation of the mineral producers and the long experience of the Geological Survey in this work gives assurance that the estimates represent very nearly the actual production. The tables show the quantity and value of the output of each mineral for five or ten years and the imports and exports of many minerals for several years.

A brief introduction points out the salient features of the mineral industry in 1919. One of the tables compares the values of commodities produced in 1919 with the values that they would have had at the average prices prevailing in 1913. This summary shows the leading mineral products of each state and the world's production of some minerals for a number of years.

A copy of this report may be obtained on application to the Director U. S. Geological Survey, Washington. D. C.

MANGANESE DEPOSITS IN COLORADO AND WYOMING.

During 1917 and 1918, when there was a shortage of manganese ore and a possibility of greater shortage, the deposits throughout the country were actively exploited, and every one reported was examined, in order to determine its probable size and the grade of material it would yield. Geologists of the State and National surveys examined about 1,200 deposits. Some valuable deposits were discovered, but many that were examined can not yield much ore.

The United States Geological Survey has just published two reports that describe manganese deposits in Colorado and Wyoming. The only deposit that was known in Wyoming in 1918 consists of manganese oxides in limestone, and lies near the head of Sheep Creek, Albany County, 38 miles north of Medicine Bow. A small quantity of rather high grade ore was shipped from this deposit.

Nine groups of deposits in Colorado were also examined, and seven of them are described in one of the reports just issued. Reports on the deposits of manganiferous ore at Leadville and Red Cliff have already been published. Four groups of deposits lie near Salida, Chaffee County; one near Iola, Gunnison County; one near Moffat, Saguache County, and one near Cedar, San Miguel County. Ore has been shipped from some of these deposits, and others could yield small quantities of high-grade ore, but probably none can be worked with profit except when, as in 1917 and 1918, a great shortage exists and prices are much higher than those now offered.

HIGH SCHOOL AND COLLEGE MATHEMATICS.[1]

BY THOS. E. MASON,

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The course of study of our high schools has been and is yet undergoing change. Certain subjects that were once found in every high school curriculum are to be found now only occasionally. The last few years have seen the once universal subjects drop out one by one. Greek is almost completely gone and Latin is vanishing. Will mathematics go next? Observe the change in subjects required for a commissioned high school and you will see the trend. We have gone from three years of required mathematics to two and now to one year, and that not the traditional topic. A high school can now be commissioned without requiring either algebra or geometry. We are still in the position where few schools do not require them. But what of the immediate future? Are we moving in the right direction? What is true of the high schools is true of the colleges to a somewhat lesser extent, because the high schools are more quickly affected by public opinion. What are the causes of the present decline of mathematics in public favor? Can we find a remedy? I want to point out to you what I consider to be some of these causes. You may not agree with me as to the causes, but a free and sympathetic discussion of the matter should be helpful.

Why did Greek and Latin give place to French and German? The reason, in my opinion, is to be sought in the manner of their teaching. The teaching of Greek and Latin had degenerated into a formal learning and repetition of conjugations and declensions and translations. Language is the medium for the transfer of thought. When it ceases to be such it loses its interest. When the teaching of these languages had ceased to be vital, some one suggested and urged that it would be more profitable to study a live language than a dead one. It was not wholly the reasons urged for the study of French and German that caused their introduction, but the dissatisfaction with the existing state of language study. We are all prone to think that the things we have not are better than the things we have. The teaching of French and German has been no more successful than the teaching of Greek and Latin. There are the same processes in the learning of any language. There is a certain amount of drudgery before we come to the place where we can appre-

[1]Read before the Mathematics Section of the Indiana State Teachers' Association, 1920.

ciate beauty of language, structure or the thought expressed in it. No magical change was wrought by changing the name of the language. The difficulty lay in the fact, that in the teaching of Latin, for example, we never went beyond the drudgery. We laid the fault to the language and not to the teaching of it. The establishment of a classical high school in Cincinnati and the fact that it is being attended shows that there are people who still believe, or who have returned to the belief, that there is something worth while in the study of the classical languages.

We are now at the stage where dissatisfaction with the present state of the teaching of mathematics is making it easy for people with new ideas to persuade the public that something else is better for their children than the study of mathematics. Do not misunderstand me. There is much good teaching. It is confined to no class. There are good grade teachers of mathematics, good high school teachers, and good college teachers; but the ratio of poor teaching to good teaching is too high.

One of the important factors of poor teaching is poor preparation. A poorly prepared teacher, in whatever position, lacks breadth of vision and so fails to see the relation of the particular subject in hand to what has gone before and to what is to follow. Mathematics becomes to such an individual only a question of problem solving. Whenever a teacher looks upon mathematics as a matter of problem solving he is like the teacher of languages who sees language as a matter of conjugations and declensions. Conditions, in general, make for better prepared teachers in the colleges. The college teacher teaches only the subject for which he is prepared. At present we have many high schools in which one teacher must care for more than one subject; so that we have a good teacher of English doing poor teaching of mathematics, or vice versa. This is not a fault of the teacher but is due to our effort to put a high school within the reach of every child. The college with its permanency of position, its freedom from the problems of discipline, etc., is constantly taking from the high schools some of their best prepared teachers. The number of college teachers is comparatively small and consequently there is better selection. The remedy for deficient preparation must lie largely with school executives. What is a superintendent or trustee to do when he needs a teacher of mathematics and there is no well prepared teacher to be had? He hires some one. It is a real problem and we as teachers must be ready to give what help we can in its solution.

There are two things that I wish to mention that lie within our power to correct. There is a belief prevalent—it has been preached for years by educational reformers—that all school work should be interesting and attractive to the child. This is a desirable condition, the doctrine sounds well and is highly thought of by the children, but is impracticable. The easy and temporarily interesting things are not always the most desirable. The things worth most usually cost most in uninteresting work. There is no place of which I know out of school where the individual does only things that are interesting. This life is made up of a mixture of interesting things and of drudgery to obtain them. Why should the school try to avoid teaching that fact? It will not be sufficient to put it as a maxim in our copybooks. The child must learn by doing that he can come to the mountain top only by climbing. Mathematics is one of the subjects, whether in grades, in high school or in college, in which there is no escaping the drudgery. Attempts to make it easy have not improved our teaching of mathematics.

The committee investigating secondary mathematics had something to say in their preliminary report about our instruction being too formal. They would probably have the same to say concerning college teaching. It is a fault that has grown gradually. The necessity of covering a certain amount of material in a given time and the effort to carry all students along tends to formal teaching. Why does a college Sophomore add fractions by adding numerators for a new numerator and denominators for a new denominator? This frequently happens. It is certainly not because his teacher of arithmetic in the grades, or his teacher of algebra in the high school or first year of college taught him to do so, or ever permitted him to do so. He simply chooses the easiest way. He knows no reason why one way should be right and another wrong. The remedy for poor methods of teaching lies in the hands of the teachers.

The change in the public attitude toward schools has tended to decrease our teaching efficiency. There was a time not far remote when only the bright boy or girl, the one intensely interested, went to high school or college. At the present time there is not the pressing economic need for the labor of children and they are free to go to school. Our laws keep them in school long enough to go through the grades and it has become the custom to go to high school and college. The result is that we

now have great numbers of students who are without a well-defined purpose. They go to school because some one else goes, or the social life of the school attracts, or for athletics, or for some other non-intellectual reason. Our classes, therefore, contain a fair percentage of students not interested in the subject matter of the course and who do not care to become interested. Their attitude is, "I am here, teach me if you can." This same student that has no desire to learn, still wants to graduate, his parents want him to graduate and if he does not pass there is trouble and everyone is unhappy. Because the college has fewer people and is farther removed from contact with the families of its students, the problems growing out of the desire to pass whether properly prepared or not come with greater force to the high schools. People have come to look upon the diploma as the desirable thing and not upon that for which it stands. Too many parents and children alike are interested, not in acquiring knowledge that life may be enriched and usefulness increased, but are interested in that magical mark that means passed. It is a situation that is affecting teachers of other subjects as well as mathematics. We can not ignore it. We may say that we are not affected by the public attitude. There may be individuals who are not but they are few. It not infrequently happens that the teacher in an effort to uphold scholarship is opposed by the school officials. Superintendents, principals and trustees are interested in making things run smoothly and are sometimes willing to sacrifice scholarship to harmony. The tenure of office is so insecure that frequently one irate parent is able to upset the whole organization. This has its effect.

The administrative difficulties caused by the fact that all the children remain in school until fourteen years of age are considerable. In order to keep the line moving to make room for those coming in each year many children are passed along whose mental attainments do not warrant it. I have been told by school men that this is bad in the high schools but worse in the grades. I can not say as to where it is worse but know that it is done. It is one evidence that our schools have not yet properly solved the problems that are presented to them. This was not a problem for the school a few years ago, for at that time a child that fell behind dropped out of school. The child can not drop out now. Seeing how easy it is to pass through the grades it tries the high school and moves the difficulty along. At every step the standard or efficiency of teaching is lowered.

Attacks on the place of mathematics in the course of study for grades and high school have been made by various people who have something for which they wish to make place. Music, domestic science, manual training, commercial training, agriculture, and art have all had their advocates and have been given a place. This could be done only by displacing something already there. I am not saying that these subjects are not worth while, but I do contend that we are so loading down the curriculum that the pupil's energy and effort are so dissipated that we lose in teaching effectiveness.

I have called your attention to a number of things which seem to me to affect all our teaching, and especially our teaching of mathematics, adversely. Do not think, therefore, that I see only the black side. It is only the dark side that needs brightening and so I call attention to it. There are in our state and in other states many well prepared teachers of every grade, although still too few; there are many boys and girls who are bright and intellectually interested, although they seem in the minority; there are parents who have high ideals of scholarship, although they seem not to be in the seats of power. Our difficulty in teaching is not new, for nearly two thousand years ago The Great Teacher said, "Because strait is the gate, and narrow is the way, which leadeth unto life, and few there be that find it."

There are two reasons which, in my opinion, justify or require the retention of mathematics in the high school curriculum. Mathematics is an exact science and after we come to the study of geometry we treat it as such. The early study of arithmetic is by the processes of the experimental sciences; we find that two and two make four by the counting of objects instead of by setting down the proper axioms and deducing the fact. In no other subject is it so clearly shown that results follow causes inevitably, for in our mathematics the causes are all set down in the axioms and there is no disputing the result. In history there may be dispute as to what results would follow a certain course of action, but there is none in mathematics. This training that a certain conclusion inevitably follows certain causes is needed to make a completely rounded education.

This is a scientific age. The natural sciences have made wonderful strides into the unknown and have applied their findings to the problems of life. Many of the things that we look upon as necessities are the developments of natural science in very recent years. There is not a natural science that does

not make use of mathematics. Unless we prepare our students with mathematical knowledge and training we shut them automatically out of the greater part of the field of science and of its applications in engineering. This we can not afford to do. We can not omit science from our lives without going back to semi-barbarity; we can not have the advantage of scientific facts without scientists; we can not have scientists without teaching them mathematics.

The problem of teaching mathematics may have one phase appearing in the high school and another in the grades and another in college; but it remains one problem—the instruction of the individual. The high schools in later years have been affected by the argument that since most of their students do not go to college, they should give their best efforts to completing the training of those who quit at the end of the high school period. This is a question that the high schools must settle for themselves. I should like to call attention, however, to the fact that there is no certainty as to who will stop; and the fact that the leaders in practically every branch of human endeavor are college trained men and women, that this is likely to remain so and that the training of the leaders, although fewer in number, is as important as the training of the ranks. I am not yet persuaded that the training which best fits for college is not also the training that is best for the individual not going to college. The thing we are working for after all is to train for living as well as to make a living. Even in this time of the high cost of living every one seems able to make a living, while few seem to know how to live. This latter is shown by the great amount of unrest, by the large numbers that are constantly seeking means of amusement to pass the time while they are not eating or sleeping or working, and by the number of books and magazines of no literary or intellectual value that are read

I want now to call your attention to the teaching of mathematics as it affects the relations of the high schools and colleges in Indiana. The high schools are sending to college each year great numbers of students well prepared in their secondary mathematics, and along with them are sending others, too large a number, who are poorly prepared but whose credentials bear the same signatures and records of credits. It may be that the teacher has said to himself, "This boy will never go on, so let us pass him and get rid of a difficult situation." Yet this boy decides to go on to college, possibly to study engineering, and

reports in due time with his credentials. He is a graduate of a commissioned high school and feels able to enter any course in college. If he chooses a course requiring mathematics he will awake to the fact that no kindness was done him by passing him when he lacked training. The awakening will come only after valuable time has been lost. Under the present plan of admission by certificate there is no way of separating the prepared from the unprepared without this loss of time. I am not theorizing now. I am talking about what is happening every year in Indiana.

Other students come with two years or one year of mathematics. How can this situation be met? How is it being met? In a liberal arts school like Indiana University it is being met by giving two kinds of Freshman mathematics. Those students who are prepared take the regular Freshman college mathematics and those unprepared take a combination of what was formerly high school and college mathematics. That will handle the situation where subsequent work is chosen that does not depend on mathematics. The situation at Purdue University in the engineering schools is different. A certain minimum of subject matter is required and not merely a certain length of time. Thus it would be necessary to lengthen the time given to mathematics in the course for students that have not had the proper amount of preparatory work in mathematics or who have had it but are too poorly prepared to do the college work. There is difficulty in giving more time to mathematics. The engineering fields have become so broad that the press of technical studies clamoring for place in the curriculum forbids giving mathematics more time. Purdue University has been permitting men to enter on condition that they make up the deficient preparation. What is the result? Here is a weak or poorly prepared student asked to carry the regular burden plus something more. The result is easy to predict. Purdue has been led by experience with these conditioned students to say that after the present year the student who enters the engineering courses must have completed the three years of work in mathematics ordinarily outlined as high school mathematics. This is saying to the student that it is better for him to take time to prepare properly before entering college than to enter poorly prepared and fail or require five years in college. It is not a sufficient answer to say to Purdue that if you want students you will have to take them as they are and provide for them. No answer is sufficient which does not center about the student. These college students

are going to be the leaders in industry and must carry on the great enterprises that affect all of us. As part of the clientele of the high school they have as much claim to consideration as any other group. The fact that Cornell with much higher entrance requirements in mathematics than Purdue has no lack of students, that the great colleges for women with high entrance standards can not accommodate those seeking admission, that other public institutions of the same character and with essentially the same entrance requirements as Purdue are crowded answers the question as to whether high entrance requirements will shut off the numbers of students.

The relation of high schools and colleges can never be satisfactorily settled by either dictating to the other. A just settlement will require that the college teachers of mathematics and the high school teachers of mathematics sit down together in an earnest and sympathetic desire to reach right conclusions, remembering all the time that the one chiefly concerned is the student. The college teacher must find out the difficulties and the problems of the high school teacher, and the high school teacher must learn those of the college teacher. It will be only then that settlement is possible.

Are the high schools making a mistake in not requiring or providing three years of mathematics? Are the college entrance requirements too severe? Should the high schools provide for the great numbers not going to college and let those going prepare in special schools? Is it possible with one group making high school graduation requirements and another college entrance standards to so arrange that there will be no break? Shall we abolish graduation and degrees and let learning be its own reward? These are all questions about which there may be honest difference of opinion. Yet they must all be answered in some fashion. Does our practice conform to the best possible answers?

In concluding I wish to present a number of things that must guide us in determining the proper place of mathematics in the curriculum and its proper teaching. No one should teach mathematics who does not believe in its value. No one should teach mathematics who has not sufficient preparation to know intimately what goes before or what comes after the subject in hand. No improvement in preparation or improvement of methods will come without the active support of the teachers themselves. Unless those of us who believe in the value of mathematics are active in its support, its place in the curriculum will be determined by some one interested in something else.

THE THEORY OF THE CHEMICAL REACTION[1].

By B. W. Peet,

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One of the most fundamental things in chemistry is the chemical reaction. It is taught or used in nearly every course in chemistry and is used for making the calculations in quantitative determinations of all substances. Chemists from very early times have endeavored to explain the cause of chemical change. It is the purpose of this paper to trace and emphasize the important things in the history of the theory of the chemical reaction.

Lavoisier has introduced into chemistry the recognition of the permanence in kind and amount of matter in the universe. To him we owe the precise formulation of the principle which sets the limit to the possible changes of matter. Many different substances may be produced by the combination in various ways of various constituents, but the amount and the ultimate properties of these constituents are unalterable.

In very early times it was recognized that bodies mutually attract each other. Affinity was the name given to the cause which produces combination between different substances. What the cause really is we know little more today than the chemist of old. When potassium combines with iodine to form potassium iodide, this reaction is said to occur because of the affinity existing between potassium and iodine; when chlorine added to potassium iodide produces potassium chloride and iodine, it is said to be due to the fact that the affinity of chlorine for potassium is relatively greater than that of iodine.

In 1720, Stahl, the founder of the Phlogiston Theory, made a classification of affinities by arranging similar substances in a series in the order in which they expel one another from a compound.

It was known from the earliest times that there is a great difference in the attraction with which different substances combine and also that there are many instances where one substance is able to displace another from a compound and take its place. Various efforts were made to measure the magnitude of this attraction and represent the relative affinities of the various substances.

Geoffroy (1718) drew up the first table of which we have any

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[1]Read before the Chemistry Section of the C. A. S. and M. T., Englewood High School, Chicago, November 26, 1920.

record. The principle was to arrange similar substances so that the one following was always expelled by the one preceding from combination with the one heading the list.

	—*HCl.*	*Sulphur*
In this table, as one goes down the column, each substance has a weaker affinity than the one preceding it.	Tin	Potassium
	Antimony	Iron
	Copper	Copper
	Silver	Lead
	Mercury	Silver
	Gold	Antimony
		Mercury
		Gold

Stahl (1720) discovered the fact that a reaction occurring at one temperature in one direction could be reversed at another temperature. For instance calomel ($HgCl$) is decomposed by silver at the ordinary temperature while under the influence of heat, silver chloride is decomposed by mercury.

Bergmann, (1775) the great Swedish chemist, found that the conditions in which a substance existed affected its position in Geoffroy's table. So he arranged two sets of tables, one for solutions and another for solids at high temperatures.

Bergmann's tables of affinity ranked with the chemists of his time in importance, comparable to that now attached to atomic weight tables. As soon as a new substance was discovered it was at once investigated with a view to settling its position in the table of "Elective Attractions."

Claude Louis Berthollet (1748-1822) did more for the theory of chemistry than any one before him. He reasoned and showed by experiment that affinity was by no means a simple force and easy to determine or measure, but was influenced by temperature, physical state, cohesion and especially by mass. The latter largely determined the course of chemical reactions.

Hydrochloric and nitric acids are volatile at temperatures at which sulphuric acid is not, sulphuric acid therefore expels hydrochloric and nitric acids from their salts. Hydrogen chloride gas is at once evolved when concentrated sulphuric acid acts on solid sodium chloride, while it is not evolved by the action of dilute acid. Concentrated hydrochloric acid solution added to a saturated solution of sodium hydrogen sulphate will precipitate sodium chloride, a reverse reaction. Hence any substance, which owing to insolubility or volatility is removed from the solution in the form of a precipitate or a gas, cannot be considered as contributing to the "active mass."

Berthollet's idea of the influence of mass received a great

deal of opposition and was not generally accepted. It remained for Guldberg and Waage (1867) to formulate mathematically these ideas of affinity, the effect of mass and the speed of chemical reaction. They stated that, "Chemical effect is proportional to the active masses," and supplied the necessary experimental evidence, and ever since Berthollet's doctrine has been generally accepted.

Berthollet's work on affinity in the form of the law of mass action is the basis of all modern work on chemical change. Beginning texts should put more emphasis on the conditions necessary for chemical reaction. Several laboratory experiments should be performed to illustrate it and demonstrations should be given by the teacher.

Experiments:

1.	$NaCl$	+	H_2SO_4	=	$NaHSO_4$	+ HCl
	Solid		Conc.			gas
2.	$NaHsO_4$	+	HCl	=	$NaCl$	+ H_2SO_4
	Saturated		Conc.		Ppt.	
3.	$NaCl$	+	H_2SO_4	$\rightleftarrows$	$NaHSO_4$	+ HCl
	Solution		Dilute			

(Perform each of the above experiments.)

These experiments and similar ones should be performed by the teacher, emphasized and then repeated by the student in the laboratory. We do not know the full explanation of the cause of chemical reaction any more than we know the final explanation of any phenomena, but we do know that temperature, pressure, solvent, and mass are important factors and we should dwell on what we know about them. I think it is quite worth while for every teacher of beginning chemistry to perform the experiment of passing hydrogen over heated copper ioxide to form water and then show that the reaction can be reversed and then emphasize that all reactions are reversible to a certain extent or tend to be reversible.

Until Sir Humphrey Davy's time—1778-1821—chemists had compared chemical affinity to gravitation. Davy held that when the atoms of two substances are brought into proximity they assume electrical charges and finally unite as the charges are neutralized. Berzelius carried the idea farther and assigned to every atom two poles like those of a magnet, upon one was concentrated positive and upon the other negative electricity. He arranged the elements something like our present table of the potential series. Berzelius says, "If these electrochemical views are correct, it follows that every chemical compound

depends entirely and alone upon the two opposite forces of positive and negative electricity, and therefore every compound substance consists of two parts united by the action of their electrochemical character since no third force exists."

Farady quite approved of the electrochemical theory and stated that chemical affinity is identical with electricity. However, he modified the theory as presented by Berzelius and suggested one quite similar with the views now generally accepte.

Conditions or Factors Which Influence the Velocity of Reaction.

It has long been known that chemical reaction takes place in solution in water much more readily than in any other form. It remained for Arrhenius, the Swedish chemist, in 1887 to suggest the theory of ionization. According to this theory most all chemical reactions in solution take place between ions. (Inorganic.) And here reactions are more or less reversible.

Experiments:

1. $AgNO_3$ (solid) + NaCl (solid) no reaction.
2. $AgNO_3$ (solution) + NaCl (solution gives a white Ppt. of *AgCl*.
3. $AgNO_3$ (solution) + $NaClO_3$ (solution) gives no Ppt.

According to the ionization theory there is no action in the first case because ions form only in solution. In the second case the silver ion unites with the chloride ion and forms silver chloride. There is chemical action in the third case but insoluble silver chloride is not formed, proving that the chlorine is probably a part of a complex ion ClO_3 which possesses altogether different properties. This is a simple experiment which is commonly used to show that chemical reactions in solution are between ions and not between atoms or molecules. It is well known that a slight excess of any reagent usually makes the reaction more complete and causes the reaction to go more in one direction than the other.

Many interesting experiments can be performed to illustrate it. For example: Pass hydrogen chloride gas into a saturated solution of sodium chloride precipitating sodium chloride or add a solution of ammonium chloride to a very dilute solution of ammonium hydroxide made pink with phenolphthalein indicator and thus make the solution colorless. Either experiment shows readily the repression of ionization or the common effect.

There are many reactions, however, that cannot be explained by the ionization theory and many that are explained by it are very unsatisfactory. Because of this many teachers of chem-

istry are looking for a more satisfactory explanation of the chemical reaction, one that will more generally explain all forms.

Professor E. C. C. Baly of the University of Liverpool published an article in the Journal of the American Chemical Society, May, 1915, on "A Theory of Chemical Reaction and Reactivity," that is very plausible and has been favorably received by many prominent chemists.

He calls attention to the fact that during the past ten years a number of papers have been published describing absorption spectra of organic compounds and the majority of the publications have claimed that there is a definite correlation between the structure of the molecule and the type of the absorption which it exerts. Recent investigations by no means favor it but the outcome of all the work is that there is definite reaction between light absorption and chemical reactivity.

It follows from the *Zeeman Effect* (resolution of spectrum lines into doublets, triplets, etc.,) in a powerful magnetic field, that the particles or atoms producing these lines possess magnetic fields of their own. These fields must possess both a polar and a quantity factor and atoms markedly different in chemical properties must differ markedly in polar factor and their force fields.

"When two such atoms approach one another sufficiently close, the force lines due to their respective force fields will tend to condense with loss of energy and with the formation of a condensed field. A *potential gradient* will be set up and if this gradient is sufficiently steep a transference of one or more electrons will take place from one atom to another, whereby a true chemical compound will be established." For example when the iron atom and sulphur atom are brought sufficiently close together, the force lines in their respective force fields condense with loss of energy. A potential gradient is set up sufficiently steep for two electrons to pass from each atom of iron to each atom of sulphur and a chemical compound is formed.

The stability of a compound evidently depends upon the condensed force field between the atoms. Before a compound can be decomposed the force field must be opened up, therefore the greater the number of force lines within the field the more stable will be the compound and the greater the amount of energy required to decompose it.

According to the force-field theory, if an acid HX is added to a base YOH an addition compound, HX.YOH is first formed

arising from the condensing of the force lines of the molecular fields of the acid and the base. A potential gradient is set up, and if sufficiently steep, the electrons will rearrange themselves with the formation of XY and H_2O. If the new system has less energy than HX.YOH a new compound is formed and we say a chemical reaction has taken place. A chemical reaction will occur only when the gradient within the complex first formed is sufficiently steep to cause the electrons to migrate. A complex between the two original molecules will be formed whether or not a true chemical reaction takes place. The recognition of this mutual influence with no chemical reaction is of great importance in pure chemistry and light absorption.

Reactions between molecules depend upon their force fields. If the force lines form a completely closed system then the molecules will possess no reactivity. Two molecules with a closed system brought together will not react. This explains why dry ammonia will not react with dry hydrogen chloride or dry hydrogen will not react with dry oxygen.

Yet in the formation of force fields they may not always be entirely closed. When the maximum possible condensing of the force lines has occurred with the maximum possible escape of energy there may be left over an uncompensated balance of force lines. This gives rise to what has long been recognized by chemists as *residual affinity*. "On the present theory, the whole of the reactivity and chemical properties of atoms and molecules is due to the force fields which have been proved to exist in the immediate neighborhood of the atoms. Chemical union between atoms, chemical reaction between molecules are both due to force fields and valence itself would seem not to be the cause but the resultant effect." Water possesses the uncompensated force or residual affinity to a marked extent. Water of hydration, $CuSO_4.5H_2O$; $H_2SO_4.H_2O$, etc., and hydrolysis are easily explained by this theory. It is well known that many reactions will take place by the mere presence of water and we have called it catalysis. The uncompensated force lines of water open up the force field of dry ammonia and hydrogen chloride and they combine.

In fact this theory offers the most plausible explanation we have of catalysis. A catalytic agent may be looked upon as a substance possessing residual affinity which has the power of opening up the closed fields of the reacting molecules to a greater extent than they otherwise would be.

The residual affinity of water opens up the force field in inorganic acids, bases and salts, a migration of electrons takes place and ions are formed. Ionic dissociation is therefore a logical sequence of the force field theory. The ionization hypothesis attributes all chemical reactions between dissociated compounds to ions as if the ions were the driving force, whereas the field force theory attributes all reactions to the opening up of the force fields of molecules whether ions are formed or not.

Effect of Light.

Force fields absorb rays of light which have the same vibration frequency as that of electrons. So a rational explanation is offered for the many reactions that take place in sunlight that will not take place in the dark.

The theory is in accord with the electron theory of matter and offers a plausible explanation of nearly all forms of chemical reaction. It is interesting to note that the more we know about matter and the cause of chemical and physical phenomena the more we know they have to deal with electricity. It has been suggested that the day is past for the mechanical explanation of nature and attempts should be made to give an electrical foundation to mechanics and all natural phenomena.

EFFICIENCY IN MARKETING FARM PRODUCTS NECESSARY.

High distributing costs of farm products have stimulated the demand for greater efficiency in marketing, declared the Secretary of Agriculture in his annual report to the President. The question of cooperative marketing, he said, has come to occupy a prominent place in the public mind.

"Producers everywhere are outspoken in their dissatisfaction with present marketing costs, which appear to exact an unduly large share of the price paid by the consumer," he said. "In their effort to reduce marketing expenses, producers are turning in many cases toward cooperative marketing. The distribution of farm products through cooperative organizations undoubtedly affords an opportunity for farmers to make more effective use of market information, to properly grade and market their products in commercial quantities, to find larger outlets, and to reduce costs and increase efficiency by shortening the channel between producers and consumers. In addition to more or less localized efforts, organizations of growers of wheat, cotton, and live stock have recently projected movements for the development of cooperative marketing on a broad scale.

"The department recognizes fully the importance of the cooperative movement and its potentialities for good in the general marketing scheme, conducts investigations relating to its status and progress, and gives assistance to specific groups of producers who request help in the organization and operation of cooperative enterprises. This work should be extended and developed."—[*U. S. Dept. of Agriculture.*

GENERAL SCIENCE IN THE JUNIOR HIGH SCHOOL.

BY H. N. GODDARD,
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It has taken a long time to recognize in general school practice, as well as in theory, the fundamental importance of the science interests of children. Indeed, it cannot be said that any adequate plan of nature study and general science for the grades below the high school has yet been put into operation in the schools as a whole. It is still true, that in the main, whatever may be said of exceptional schools or exceptional teachers, most instruction work is too exclusively formal and abstract. There is too little approach to the conventional and highly organized fields of knowledge and thought through the concrete and the objective. There is too little development of knowledge through the motives and thought processes which are most effectively stimulated by concrete situations and by the practical problems naturally arising out of these contacts with things. Furthermore, the formal type of laboratory study which has been developed in the high school with its problems and methods imposed from without, and largely foreign to the pupil's immediate experience, has not remedied, even in the high school, the great weakness in education so well pointed out by Chas. W. Elliot in his monograph on "The Concrete and Practical in Modern Education."

It has been the problem of general science during the last few years to work out on the basis of our best knowledge of the science of education, the means and methods of making science study more effective as an instrument of education. As has been the case, to a large degree, in all problems of education, the method of attack has been from above downward rather than from the lower levels up in accordance with all growth processes. General Science has therefore been considered up to the present for the most part, as a high school problem. It is only with the development of the Junior High School idea that we have been forced to carry the study back into the seventh and eighth grades.

Let us, in this paper, make the attempt to build up from below rather than to follow the usual from above downward method. Let us assume at the start the truth enunciated so many years ago by G. Stanley Hall, that "Nature Study is the fundamental subject matter of education." It follows that no system of education can be regarded as efficient or complete that does not give

large place to a study of the interests and relationships of children to the natural world, which constitutes the natural environment of every boy or girl from infancy up. The child then comes to the first year of the Junior High School with a rich and interesting experience in the world of things. Nature makes a strong appeal to him because of its wide freedom and because of its pleasing relationship to his own pleasurable activities. At this stage his mental activities are stimulated most strongly through his senses, and nature furnishes an inexhaustible array of new and strange materials which please the eye, attract the ear and stimulate the imagination. Again, all his racial tendencies lead him to love the fields, the woods, the streams and the out-of-doors. Furthermore, since his own organism finds most natural and most pleasing expression through activity, he finds his most ardent interest in activity in the material work about him. Nature, and especially living nature, furnishes this activity in never-ceasing cycles. This appeal is especially strong because of the constantly changing scenes and situations which nature affords. A large part of every child's education ought to consist in making conquest of this strange and ever changing world. This interest in activity soon develops an ardent desire to discover what things in nature can do, and then the child wants to know how they do it. It should be noted that living, changing, active things and the spacious out-of-doors make the strongest appeal.

In the upper grades also, the eager desire to appropriate nature's resources and the ability to manage and control her forces for useful ends become dominant interests. Likewise, the love of adventure and thrilling experience shows itself in interest in wild animals, in fondness for hunting and in the experiences of woodcraft generally.

The schools have given entirely too little recognition to these fundamental interests of child nature. They have been entirely too slow in modifying the usual stereotyped classroom methods and the fixed school programs in such a way as to take advantage of these well-known child interests and tendencies. We have left the Boy Scout movement and similar organizations to develop effective programs in this line. Much high school botany and other science as well, which might have made a strong appeal to interest and effort, has been dead and fruitless because of failure to make adequate provision for this side. It is not so much information about nature or even laboratory experiments

with natural phenomena, that makes the strongest appeal to the child. What he wants is sympathetic acquaintance with nature and an understanding of her ways. This should lead to right attitudes which are as much moral as intellectual, and which should finally develop both a knowledge and a spirit leading to the conservation of useful things and the control of those that are harmful. Educationally, this study not only develops sympathetic knowledge, but provides also a most vital intellectual training, and a concrete experience which is able to vitalize much of the more formal work of the school as well as give the best preparation for future science work.

With the desire to appropriate nature's resources and be able to manage and control her forces, go a desire for ownership and a joy in the possession of some created product. The results of productive enterprise make a strong appeal. The boy wants to be a man and have a part in man's achievements. The applications of science in invention and in practical utilities such as electric power, telegraphy, wireless and manufacturing processes arouse the keenest interest. Gardening, poultry work and other phases of agriculture develop quick and eager responses.

All these natural interests and rich nature experiences are capable of furnishing at this stage the most valuable materials for the development of useful scientific knowledge, for training in scientific methods of thought and for leading pupils to an appreciation and some command, at least, of useful scientific processes. Science is tritely defined as organized and classified knowledge. Pupils' scientific experiences up to this stage have been largely undifferentiated and unorganized. They have thought little of the meaning and significance of nature phenomena. Much less have they appreciated or understood the relationships or the principles involved. Many of their observations have been incomplete and inaccurate. This body of experience becomes at this stage naturally and easily the constructive material for the beginnings of science. The problem of the science teacher here is first of all, to help the pupils reconstruct and organize this knowledge on the basis of relationships which they can understand, and then give them opportunity for the study of new and larger problems by means of new situations and in a more scientific way. In other words, pupils should at this stage have the opportunity to begin real science study.

This development and organization should not be from the

logical order viewpoint of the mature mind. Neither should it be imposed upon the pupil from without. Much of the weakness and failure of science teaching in the past has resulted from these causes. On the other hand, pupils should be led to organize and generalize their knowledge as far as they are capable of understanding relationships and principles involved. It is only such generalized knowledge and experience which is capable of useful applications to new situations. It is only such knowledge that has real educational value as distinguished from empirical, rule-of-thumb information. It must be kept in mind further that scattered and more or less hazy notions about things and natural phenomena, may have little of either scientific or of educational value. Much general science of the last few years has been weak at this point.

From all these considerations, it would appear that general science is the subject or field of study "*par excellence*" for the Junior High School. It appeals to natural interests; it develops a strong motive; it stimulates active imagination; it provides ideal training in inductive habits of thought; it furnishes abundant opportunity to combine seeing and doing with thinking and knowing, and it gives a large command of nature's forces and nature's laws for useful productive enterprise. Not only are these conclusions justified by theoretical considerations, but they are confirmed by the experience of every capable teacher who has tried to present in a concrete and practical way, simple lessons in general science to pupils of Junior High School age.

What then is needed in developing an effective program of general science for the Junior High School? First of all, an effective curriculum should be worked out in such a way that it will articulate well with the nature study below and at the same time lead naturally and progressively to the science of the Senior High School. Up to the present time, there has been great confusion and considerable disagreement in regard to the grades or years in which general science should be taught. Most commonly it has been placed in the ninth grade, or first year of the four-year high school. Many have advocated extending it through the tenth year. A few have even proposed to substitute a program of general science throughout the high school in place of the differentiated sciences which have commonly been a part of the high school curriculum. Below the four-year high school, there has been some attempt, though

in a rather indefinite way, to introduce this work into the seventh and eighth grades. This attmpt has been argumented by the development of the Junior High School organization. In the effort to develop an enriched curriculum in this school, general science has usually been given at least some consideration. There has been, however, little systematic plan in the work and there has been much overlapping and duplication as the work has advanced from grade to grade.

At least, the work could be made much more effective both from the standpoint of the pupils and of the teacher, if a systematic plan could be worked out showing in what grades the work should be given and what should be the character of the work in each grade.

The State Department of Education of Wisconsin has recently issued a new program of studies for the four-year high school in which a year of general science has been required of all students. This has been arranged to run through both the ninth and tenth years on the fractional unit plan, and alternating with citizenship in such a way that both subjects run through the two years, and one-half a unit of each is completed each year. This plan was believed to have the advantage, especially in the case of citizenship, of giving pupils a longer period of contact with the practical problems of civic and social life. This idea of the longer period of contact may be of advantage in the general science although it is the opinion of the writer, who helped work out the State Department curriculum and who is now trying it out in his own school, that ultimately the best adjustment will be found by completing the general science in the ninth grade, leaving the last three years of the high school, or in other words, the senior high school period, for elections in the differentiated sciences, one year of which at least, would be required of all students. The suggested arrangement for these would be a year of biology in the tenth year, a year of chemistry in the eleventh, and a year of physics in the twelfth with such geography, physiology and other science as may be found possible. The biology should not be the strictly evolutionary or logical order type but should be a practical study of plants and animals with such differentiation as is found most effective in an administrative way. Whether this year's work should be half a year of botany and half a year of zoölogy or whether it should be a less differentiated type of work such as that presented in Hodge and Dawson's "Civic Biology" had probably

better be left to be considered as a local problem of administration depending on experience of teachers, laboratory accommodations and available text and reference books for the work. With experienced teachers and abundance of reference material, the writer would prefer the undifferentiated plan. With the perfection of the Junior High School organization, to include grades seven to nine inclusive, this would throw all the general science back into this school. This outcome would concentrate the problem of curriculum making and course of study outlining so far as general science is concerned in the one school, which would at least be an administrative advantage wherever the Junior High School organization has assumed this standard form. Perhaps the same plan would also adapt itself readily to situations where the two-four plan exists.

The scope of this paper does not permit entering into much detail as to what the content of the general science should be according to this plan. I can only make a few general suggestions. In the seventh year, the work might be largely of an agricultural type. The science side might be most emphasized in the first half of the year and this merged in the second semester into gardening, poultry or other project work. Again, the whole year might be given to the agriculture with such science teaching as could be brought into the study in a functional way. Then I would suggest special emphasis on the life side during the eighth grade. Pupils at this age love to collect such material, and delight especially in the study of plant and animal activities. Besides, these studies seem to have the advantage here of effective correlation with the previous study of agriculture aforementioned for the seventh grade. It is not considered essential that the study here should be confined wholly to the life side, but mainly for administrative reasons, it is believed the main emphasis should be so placed. Again, this helps to avoid the deadening of interest by duplication and repetition which are almost sure to occur where similar material is dealt with in successive years. The pupil who has started some interesting life study in the eighth grade will come to the biology in the tenth year with an appetite developed and with a capacity for an understanding of new and larger problems. Furthermore, if the exploratory and discovery idea of the Junior High School period is true, it is important especially in the general science that the pupil should have opportunity to explore the entire field of the fundamental sciences during this period. If the life

study is given main emphasis in the eighth year, the ninth year is left for main emphasis on the physical side. Experience during the present year with plant and animal study in the eighth and physical science in the ninth year has given the writer especial confidence that this plan lends itself well to effective results.

It is probable that some will contend that this is the old subject-matter viewpoint, and that the fundamental basis of organization of the general science should be the project plan in which boundaries between the various fields of scientific thought should be practically eliminated, and where the whole study should be organized by project rather than on any subject matter basis. The writer is ready to accept this contention to a large degree, at least, on theoretical grounds. Nevertheless, as a result of considerable experience both in attempting himself to present the subject on the project plan, and in observing others, it is a firm conviction that at present even the stronger teachers, to say nothing of average teachers, are unable to round up successful results in general science teaching without concentrating at any one time or period upon problems within certain definite fields of study. In other words, problems must be organized within certain general topics or limited areas of subject matter. This will continue to be true, certainly until teaching materials have been much better organized on the project plan than at the present time in available texts. This is not only true on pedagogical grounds, but for purely administrative reasons as well. It is too great a task for the teacher to keep on hand ready for use at any time in the class room, various kinds of apparatus and illustrative material adapted to the needs of all phases of study. Again, it is also true, that there must be concentration upon some one problem, or phase of study, related to a particular situation in order that results of real scientific value may be secured.

Another important need of general science in the Junior High School is a recognition of the fundamental importance of adequate laboratory accommodations and equipment for this work. Here again, our development has been by the usual course; viz., from above downward. Trained teachers and fine laboratory equipment were first supplied in the colleges and universities. Later, covering the period of recent years, much attention has been give to such equipment in the high school, though many small high schools are still poorly supplied. Little has yet been done in the grades where the need has always been fun-

damental. Fortunately, recent study of Junior High School problems and methods is focusing attention upon this need. It should be an immediate problem to develop some definite standards in this matter. Such equipment should include liberal sized science laboratories, tables on which pupils may work with concrete materials, suitable apparatus, an abundance of illustrative material, and suitable cases where such material may be kept ready for use. The kind of equipment should, of course, be of a kind adapted to the special needs of these grades. It need not be, in fact, should not be, of the expensive type found in the larger high schools. It should, however, provide abundant opportunity for pupils to work under the direction of the teacher with concrete material in their hands. It should furnish convenient and effective means by which pupils may make careful observations leading to accurate conclusions and where concrete demonstrations may be given frequently by both pupils and teacher. Demonstrations by small groups or teams of pupils are especially valuable. The methods of the Boys' and Girls' Agricultural Clubs are well worth study and imitation in this connection.

A type of equipment which is of special importance in these grades is that needed for keeping living plants and animals where their activities may be observed by pupils from day to day. Every one knows how unbounded are the enthusiasms of children in the study of such material and with what eager interest they help in its collection. There ought to be in every Junior High School, that deserves the name, an abundant supply of aquaria, animal cages, growing plants, and other such material. A good window garden or small green house might well be made a standard requirement for science work in every Junior High School. The need of this is believed to be, from the pedagogical point of view, of even greater importance than in the high school or college. Whoever has seen the Gary Schools, whatever he may think of them in other respects, can scarcely fail to admire and approve their provision for science study of this kind in the grades. At any rate, any one who has studied to any degree the needs of science in the upper grades will agree that there is just as much need of definite provision for adequate laboratory and demonstration work in these grades as in the high school.

For years the writer of this paper has preached the fundamental importance of science study with children. The special values of this study can scarcely be questioned in the light

of our present science of education. We have attempted here to restate something of the pedagogical significance of this problem in the development of the adolescent child, not only because of its strong appeal to natural interests and its ease of motivation, not only because of its practical relations to modern industrial life, not only because of its valuable training in inductive habits of thought, but also because of the possibility of furnishing through this study an adequate, concrete basis for the vitalizing of all other school work.

The writer has often made the statement that the time would surely come in American education when adequate provision for effective work of this kind by means of properly outlined courses of study, suitable laboratories and equipment, and finally, teachers especially trained to teach science to children, would be regarded as just as essential for the grades now included in the Junior High School, as adequate provision for science in high school or college has for years been considered. There are signs that this time is rapidly approaching with the study and emphasis which are now being given to this new type of intermediate school.

Science teachers can do no greater service in connection with their special field of work, than to secure prompt and general understanding of this need and to work out plans and standards which shall receive general recognition in educational practice. The coming of the Junior High School and the new awakening in connection with its problems will greatly help to hasten such accomplishment. As new school buildings are constructed and as old buildings are more and more adapted to the recognized needs of the new type of work, there should be a decided and definite demand for full provision for the science work.

AREAS BELOW SEA LEVEL.

All the continents possibly, except South America, include areas of dry land that lie below sea level. According to the United States Geological Survey, Department of the Interior, the lowest point in North America is one in Death Valley, Calif., that lies 276 feet below sea level, but this depression is slight compared to the basin of the Dead Sea, in Palestine, Asia, where the lowest point on dry land is 1,200 feet below sea level. The lowest point in Africa is one in the Desert of Sahara that lies about 150 feet below sea level. The Sahara as a whole stands above sea level, although until recently the greater part of it was supposed to lie below sea level. The lowest point in Europe at present known is one on the shores of the Caspian Sea that lies 86 feet below sea level. The lowest point in Australia is one at Lake Torrens that lies about 25 feet below sea level.

GENERAL SCIENCE IN THE STATE OF WASHINGTON.

By A. A. Douglass and H. Noel Bakke,
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During the latter part of the school year of 1919-20 a questionnaire was sent to the high schools in the state of Washington, to learn the status of the course in general science. The following table shows the number of schools having a general science course, and compares Washington with the North Central Association[1]:

	R'p's	Having General Science		Not ha'g General Science		Length of Course				Will add General Science	
						Semester		Year			
		No.	%	No.	%	No.	%	No.	%	No.	%
Washington	210	160	76	50	24	15	7	145	69	14	6.6
N. C. Assn.		534	52	498	48	189	18	345	33	....	....

General Science is found in such a large majority of the schools of this state and is so often offered in the ninth grade that it may be regarded as one of the regular courses for high school freshmen. From the foregoing table it will be seen that in comparison with the North Central Association, as a whole, general science is much more common in Washington. Colorado, Iowa, Kansas, Nebraska and South Dakota, of the North Central Association, have general science in approximately 70 per cent of the schools reporting. The extent of general science in Washington high schools is further shown by the fact that 18.9 per cent of all the students enrolled in the high schools returning the questionnaire take the course, while 24.4 per cent are enrolled in special science courses. In 45 high schools general science is required for graduation, in 100 it is not required, and in 10 the course is necessary for graduation in science curricula. Thus it seems that the course has a great drawing power.

A tabulation of the aims and values of the course as listed by those replying to the questionnaire shows the same chaotic condition that is found elsewhere, as well as dissatisfaction with the course on the part of a considerable number. Howe[2] found the dominant purposes of general science, as listed by 80 teachers of the subject, to be "to give each pupil the greatest possible understanding, appreciation, and control of his everyday environment, to acquaint him with some of the most important industrial and social applications of science, and to furnish as wide a fund

[1]Bureau of Education, Bulletin, 1919, No. 45, p. 93.
[2]School Science and Mathematics, Vol. 19, pp. 248-255.

of information about nature and science as time permits." These aims are frequently stated by Washington teachers, but that aims are not clearly defined and therefore do not control subject-matter is indicated. Much more important, judging from the number of times mentioned, is the foundation for the later sciences and the aid in selecting subsequent special science courses which general science is supposed to give. Sixty-three per cent of those replying to the questionnaire are favorably disposed to general science, although more than half have some criticism to offer or some qualification to make. These criticisms and qualifications in most cases have to do with the training of teachers, textbooks, and the presentation of the subject. Twenty-two per cent give no opinion as to the value of general science, and 15 per cent express themselves as not in favor of it, largely because of its composite nature. Thirteen additional schools have for various reasons dropped the subject.

The text is usually a fair index to the subject-matter of a course. Making use of this criterion, general science courses in Washington lack unanimity and coherent organization. The need of a definite statement of aims is again emphasized. Nine different texts are used, but none seems entirely satisfactory. Nearly 50 per cent of the schools do not follow the order of topics as given in the text used. It was thought that a correlation might exist between the "satisfactory" texts and the order

	No. Schools Using Text	Is the Text Satisfactory?		Do you follow order of topics?	
		Yes	No	Yes	No
Hessler First Year Science	59	30	29	32	27
Caldwell and Eikenberry General Science	21	15	6	7	12
Snyder Everyday Science	24	15	9	13	10
Clarke Introduction to Science	12	8	4	7	4
Elhuff General Science	8	4	4	2	3
Lake General Science	5	4	1	2	3
Pease General Science	4	0	....	....	....
Trafton Science of the Home	1	1	....	....	....
Van Buskirk and Smith Science of Everyday Life	2	2	0	1	1
Totals	136	79	53	64	60

of topics followed, but examination showed no such relation to exist. The preceding table gives a summary of the textbook situation.

In many cases supplementary texts and references are found, although 10 per cent of the teachers admit they use only the textbook. Thirty per cent mention another general science text as their chief source for reference work; 21 per cent, textbooks in physics, chemistry, physiography and other special sciences; and only 6 per cent make use of scientific bulletins and periodicals. Thirty-three per cent did not answer the question.

The amount of time devoted to laboratory work per week and the person or persons performing the experiments are shown in the following table. The periods are, with a few exceptions, 40 minutes in length.

Number of Schools	Periods per week	Experiments performed by		
		Pupils	Teacher	Both
12	0	2	6	4
19	1	0	10	9
65	2	25	9	31
5	3	2	0	3
14	4	6	1	7
5	5	4	0	1
1	7	0	0	1
3	*	0	3	0
124		39	29	56

From this it seems that on the one extreme there are several schools which offer only a textbook course, while on the other there are schools which depend almost entirely upon the laboratory method of instruction. Fifty-two per cent of those answering the question allow two periods per week for laboratory work. It is interesting to note that in only 31 per cent of the schools are the experiments performed by the pupils, while in 24 per cent the pupils have no part in the experiments and in 45 per cent they share this work with the teacher.

Seventy schools, or 44 per cent of those answering the question, purport to teach by the problem method; 25, or 17 per cent, claim they use this method in part. Fifty-six schools, or 37 per cent, say they do not teach by the problem method. Judging from the amount of time spent in the laboratory and from the fact that only one of the texts used in this state (and that particular text by only a few schools) is written from the problem or project standpoint, it is doubtful if the meaning of "problem method" is clear.

Very few of the Washington general science teachers have had special training. In the small high schools the course is frequently assigned to the teacher who has the time to teach it with little regard to his fitness. To the question, "Has your general science teacher had special training?" 154 answered in the negative and 11 in the affirmative. An examination of the "special training" shows that in some cases it consists of a summer course in general science or more meager training. Replies to a request for suggestions for training general science teachers show a lack of grasp of the fundamental principles underlying general science. Sixty-one gave answers to the effect that acquaintance with the various fields of special science would constitute requisite training; twenty believed that a general science course in college is necessary, and thirty-one spoke in terms of a viewpoint on the part of the teacher which would make for acquaintance with the everyday environment and social and industrial applications.

Summarizing, we may say that general science is a ninth grade subject in three-fourths of the high schools in the state of Washington, and that it is taken by nearly all of the students in the schools where it is offered. A majority of school men express their belief in the subject, although many criticisms are made. There is no unanimity as to the purposes of general science, although there is considerable agreement that it should serve as a foundation for later work in the special sciences and should aid the pupil in selecting later science courses. There is the widest diversity in the amount of time given to laboratory work, in the material included in the course, and in methods of teaching generally. General science teachers have had almost no special preparation for their work. There is the greatest need for a clear statement of the aims of general science, for subject-matter that is intelligently organized, and for facilities to train the teachers who are to handle this work.

THE BULL MOUNTAIN COAL FIELD.

The Bull Mountain coal field, in Musselshell County, Mont., according to an estimate made by the United States Geological Survey, contains nearly five billion tons of coal. A small part of this immense reserve of coal has already been mined, but by comparison with the total in the ground, the quantity mined is practically negligible. This coal field is described in Bulletin 646 of the Geological Survey, a copy of which may be obtained free of charge on application to the Director of the Survey at Washington.

WHAT THE BUSINESS WORLD DEMANDS OF GEOGRAPHY[1].

BY FRED K. BRANOM,

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COMMERCIAL AND INDUSTRIAL UNITED STATES.

The United States has become the leading nation of the world. This country is moving slowly towards the goal which God has made possible, by giving us an abundant supply of many natural resources such as fertile soil, coal, petroleum, iron, copper, and lumber. We have more than one-half of the coal of the world and we are producing about one-half of the world's coal and iron, four-fifths of the copper, two-thirds of the petroleum, two-thirds of the aluminum, one-half of the lead and zinc, three-fourths of the corn, one-fourth of the wheat, one-half of the pork, and two-thirds of the cotton.

The industrial life of any great nation depends upon cheap power, which means at the present time cheap coal. The commercial and industrial life of England is founded upon coal, and without coal England would be an agricultural country supporting only a small number of people. Likewise the United States is the foremost manufacturing country in the world, chiefly on account of cheap coal and raw material.

During the last fifty years, the foreign trade of the United States has increased from a little less than \$1,000,000,000 to more than \$12,000,000,000. Before the war the domestic trade received most of our attention. The war gave us a large foreign trade because of the unnatural conditions in Europe and because many nations were forced to do business with us, which hitherto had done most of their trading with European countries. With the return to natural conditions, competition will become keen and ordinary economic laws will prevail.

Exports make up about two-thirds of our foreign trade and almost any article which we manufacture may be sold abroad. Hence every section of our country has an interest in our exports. An automobile manufactured in Detroit and sold abroad does not give work only to the people of that city, but to a large number of people in many parts of the United States. In the manufacture of an automobile are used many materials such as iron, copper, lead, and nickel, produced in the states bordering the Great Lakes, Alabama, West Virginia, Pennsylvania, Tennessee, Kentucky, Missouri, and the Rocky Mountain States; cotton raised in the South and made into cloth in the mills of the South

[1] Read at the November meeting of the C. A. S. and M. T. at Englewood High School, Chicago.

and North; leather from animals raised on the Western Plains, slaughtered in the states bordering the Mississippi River, and tanned in the Eastern and Central States; lumber from all sections; and chemicals, paints, varnishes, and electrical goods from the Central and Eastern States.

The United States has the greatest shipbuilding facilities in the world, and the country ranks second in steam tonnage. In 1914, the United States' percentage of the world's seagoing tonnage was less than five per cent, in 1920 it was twenty-four per cent. Today our flag is seen in various parts of the world and much of our foreign commerce is carried on in our own vessels.

The future greatness of the United States is assured, and we will soon be manufacturing and carrying the trade for one-half of the world. If we are going to take advantage of the wonderful opportunities which lie before us, we must understand the geographic, economic, social, and political conditions not only of our own country but of the rest of the world. An understanding of the geographic factors of the various regions will tend to cultivate a friendly feeling between us and all nations, and we will not dislike them because we are different.

Information Sought from the Business World.

Since the business world depends for its existence upon geography and since most of our students enter some phase of business, we geography teachers should be guided to a large extent by the needs of the business world. With this in mind a questionnaire was sent to more than sixty of the leading business concerns of the country which employ a large number of people.

The following questions were asked:

(1) Do you believe that enough emphasis is put on place geography, i. e., the location of places, in our public schools?

(2) Do you believe that there are some continents which do not receive enough attention in the grades? If so, what continents?

(3) In some schools the geography work of the eighth grade consists chiefly of (a) commercial geography and (b) a study of the home state and of the city in which the school is located. Do you consider this a good plan?

(4) Many pupils do not enter high school but go to work shortly after completing the eighth grade. Do you believe that the school is training the pupils as well as it might in geography? If not, what have you to suggest in the way of improvement?

(5) According to your opinion, what are a few of the chief geographic facts or principles that a pupil should know when he completes the eighth grade?

(6) According to your judgment and experience, do high school graduates have as much knowledge of geography as they should?

(7) In a four-year high school where a certain number of courses are required, how many of the courses should be geography? Of what, in general, should each course consist? In what year should each be given?

(8) In a four-year high school where electives are offered, what electives should be given in geography? Of what, in general, should each elective consist?

(9) What have you to suggest in the teaching of geography in the high schools?

(10) According to your opinion, do the average college men and women know as much about geography as they should?

(11) In general, do our colleges and universities offer enough courses in geography?

Thirty-four answers were received which represented twenty-five different lines of industrial activities. A few answered all the questions while some omitted certain ones.

INFORMATION RECEIVED.

To the first question, "Do you believe that enough emphasis is put on place geography?" Twenty answered no, two yes, two did not know and two gave indefinite answers.

To the second question, "Do you believe that there are some continents which do not receive enough attention in our public schools, and if so what continents?" One reply was indefinite and one said that he did not know. Two said that more time should be put on Europe, four on Africa, six on North America, eight on Australia, fourteen on Asia, and eighteen on South America. One writer expressed his opinion in a clear way when he said that he believed "that more emphasis might well be placed upon the study of South America and the Oriental countries, especially in connection with industrial geography. Undoubtedly our new international relations are going to make it more essential for the coming generation to have a firmer grasp of both industrial and place geography of continents other than ours."

The third question was, "In some schools, the geography work of the eighth grade consists chiefly of (1) commercial geography and (2) a study of the home state and of the city in which the school is located. Do you consider this a good plan?" Twenty-four answered yes for commercial geography and one answered no. The person answering no said that "A review of locational geography of all continents should come in this grade, not in too much detail but sufficient to leave with the pupil a far better idea of the map of the world than he now gets." Fourteen favored teaching the geography of the city and of the state, but eight could see no good reason for putting more time on these than on other important regions. One answer was, "I consider commercial geography essential but I have thought that too much stress is being laid on the study of the geography of the

state and city in which the school in question happens to be located. The pupil naturally has a more adequate idea of the geography of his home state and city than he has of others, and information concerning them is more readily available to him outside the school than is information concerning other states. It would seem to me that the method of teaching geography should not sacrifice broadening education for the more specific or utility education." A part of another answer was, "Owing to present transportation facilities and the practice of individuals leaving their home community for business reasons, we do not see any benefit in stressing the study of the home state above that of other important sections."

The fourth question was, "Many pupils do not enter high school but go to work shortly after completing the eighth grade. Do you believe that the school is training the pupils as well as it might in geography? If not, what have you to suggest in the way of improvement?" To the first part of the question, eighteen answered no and ten said that they were unable to answer. One answer, which is somewhat typical of the others received, was as follows: "No, I do not think that the school is training the children in anything as well as it might, for if it were we would have reached perfection and would have nothing more to strive for. Geography was one of my favorite studies when I was a boy, and I was one of a few who studied it all winter. A map has always had a fascination for me; and this is the way I think geography should be taught. I think the maps should be in relief, for this would give the pupil at a glance the mountain ranges and river systems, and would give an idea of the character of the different parts of the globe with respect to agriculture, water-power, etc.

"In the second place, I think our schools try to teach too many details. The details should be in the geography, but the pupils should not be required to memorize too many of them. Let them memorize a few and then turn to the book for what they need to know with respect to detail. I'll warrant there isn't a teacher in your Normal College outside of the department of geography who can bound every state in the American Union, and yet we insist on the children learning boundaries of states. It is of no particular use. Whenever it is required it can easily be picked up from the book. Teach the children the general divisions of the country, and let them learn in a general way where the states are and where the principal cities are, but don't

get down to little towns of ten or twenty thousand inhabitants, excepting in one's own state, where details might be made a little more complete."

Another answer along similar lines was "The classes are not made interesting enough in all cases. I would suggest that, in connection with geography courses, books of travel be used, such as Carpenter's Geographical Readers. A jigsaw puzzle also can be obtained. This puzzle consists of separate states of the United States which the student puts together. I have seen students who have brought these puzzles home from school, work at them with the greatest interest, and they can tell exactly where each state in the Union belongs. I also would suggest games such as "The World" put out by Mrs. Decker, 125 Purdy Street, Buffalo New York. Emphasis should be put on the climate, products, etc., rather than on the mechanical learning of capitals, cities, etc. It would also be well, I believe, to have samples of products from various sections of the country."

To the question, "According to your opinion, what are a few of the chief geographic facts or principles that a pupil should know when he completes the eighth grade?" many valuable answers were received. The following quotations will give an idea of some of the things which many believe an eighth grade student should possess:

"It is our belief that a boy or girl completing the eighth grade in our public schools should have a considerable general information about every continent and country on the globe, giving considerable attention to the matter of the geography of the United States. Each pupil should be able to locate every state in the union, to know the capital of each state, to know the principal cities of each one, and something about the manufactured products that come from each state, the industries which are located in the different sections of the country, which natural products are found in different localities, something about the navigable rivers and lakes, and some knowledge of the trunk line railroads."

"A pupil should have an idea of the relative locations of the hemispheres, continents, nations, and metropolises. He should have adequate ideas of distances and a working knowledge of latitude and longitude. He should have a smattering of astronomy, naturally in its very elementary form. He should know the relation of industries to communities and the interdependence of population. He should have a knowledge of place geography. He should know enough physical geography to per-

mit an understanding of the drainage systems and the formation of the land. He should know something about the races, their characteristics and the effects of climate upon life."

To the question, "Do high school graduates have as much knowledge of geography as they should?" twenty-six answered no.

The seventh question was, "In a four-year high school where a certain number of courses are required, how many of the courses should be geography? Of what in general should each course consist? In what year should each be given?" Fifteen answers were received and the number of courses that should be required ranged from one to three. Four said that political geography, seven that physical geography, and twelve that commercial and industrial geography, should be required.

The eighth question was, "In a four-year high school where electives are offered, what electives should be given in geography? Of what, in general, should each elective consist?" Only a few felt able to answer this question. Of the fourteen answers received, six were indefinite. Eight said that electives should be given and mathematical, astronomical, economic, commercial, physical, state and city geography were mentioned.

To the question, "What have you to suggest in the teaching of geography in the high school?" fifteen gave rather clear answers. The following quotations are typical of the answers received. "Deal more with causes and results. Enough time is spent on the subject to fix some definite information which may be of future use."

"The courses should be made interesting. Emphasis should be put on products, climate and physical features. For instance, a student might be given the task of routing a salesman through the southern states, the student to be furnished with the points that the salesman would be supposed to cover. He could lay out the route, indicate the railroads to be used, and could check up to see about what the fare should be between the different points in order to see that the expense accounts were correct."

To the question, "Do the average college man and woman know as much about geography as they should?" four answered yes and eighteen no.

To the question, "Do our colleges and universities offer enough courses in geography?" eight said no and five yes. One answer was, "The schools of business administration are coming to appreciate the importance of geography, and are taking steps to

remedy the defects to be found in the older academic courses."

CONCLUSIONS.

From the data which have been collected, of which the substance has been presented, the writer has drawn the following conclusions:

(1) That place geography should not be neglected in our public schools.

(2) That in most schools, more emphasis should be placed upon South America, Asia, and Oceania.

(3) That a course in commercial and industrial geography in the eighth grade is desirable, and that state and city geography should not be neglected.

(4) That when a pupil leaves the eighth grade he should have a general knowledge of geography which he may use later. The school should pay less attention to minor points and more to big problems. The subjects should be made live and interesting and too much should not be attempted.

(5) That, in general, high school graduates have a poor knowledge of geography.

(6) That in a high school, of the required courses, two or three should be geography. One course might be the principles of geography, another economic and industrial geography and a third commercial geography. A sufficient number of electives should be offered.

(7) That the problem method of teaching geography in the grades and high school is desirable.

(8) That the average college men and women have little knowledge of geography, but that many colleges are introducing courses in their curriculums to overcome this defect.

(9) That the business world recognizes the importance of geography. This is shown very clearly in the following letter received from a large manufacturing concern: "We do, however, believe that geography is of great importance and that in the past there has not been sufficient emphasis placed upon the proper study of this subject.

"The real thorough study of place geography and of commercial geography combines with it so much of history and business that it is almost an education in itself, and any efforts made to give more thorough training along these lines would be valuable.

"In business, particularly at the present time, the question of foreign trade is continually coming up, and it is of the greatest

importance to have some one in an organization, or better yet, several members of an organization who are real experts in commercial and place geography. For this reason, if for no other, we believe it would be time well spent for any one expecting to go into business to make an exhaustive study of this great subject."

A similar line of thought is expressed in the following letter received from a large sugar refining company: "We believe that a thorough grounding in geography is very valuable, especially in these days of intra-state business. In our business, the sugar business, it is of great help to have a student know the various sugar growing countries, their location, population, weather conditions, transportation facilities, etc. I most certainly believe that a thorough grounding in world geography, together with commercial history or statistics of the various countries, would be of value in any business today."

Hence the problem of the geography teacher is a live one, for geography is one of the subjects which trains a person not only for business; but it trains him as an individual, as a citizen, and as a future ruler in the affairs of the nation. The aim of education is to produce men and women and not narrow-minded individuals, to produce a sympathetic class of people and not a stratified society.

HOW DO RAINDROPS FORM?

The stereotyped explanation of the formation of raindrops contains some rather striking fallacies. It is assumed that when air is cooled below the dew-point condensation occurs on the nuclei present; that the larger droplets, owing to their lesser vapor tension, grow at the expense of the smaller; and that the larger and more rapidly falling drops coalesce with others on their downward path to form full-sized raindrops. Dr. W. J. Humphreys, who dealt with this subject at the last meeting of the American Physical Society, pointed out that the number of condensation nuclei in a given volume of air is ordinarily so great that the amount of moisture present could not form drops as large as raindrops around them. In fact, the available space would not hold as many raindrops as there are nuclei. It is true that the larger drops do grow at the expense of the smaller, but according to theory, at a rate far too slow to be effective in the process of rain production. Lastly, even if a droplet should fall quite through a cloud layer and actually coalesce with all the particles in its path, the chance of its thus becoming a full-sized raindrop would be very small. Dr. Humphreys explains rain formation thus: Humid air ascends and forms cloud droplets on the nuclei present as soon as the air cools below the dew-point. The drops in the lower part of the cloud thus formed filter out most of the nuclei from the air ascending still higher. Thus at upper levels there are so few nuclei that a drop of "falling" size can form around each of them. These drops doubtless often grow larger through coalescence with other drops during their fall. The last process is facilitated by the electric charge which the drops usually have. —[*Scientific American.*

FORESTRY IN THE MISSISSIPPI VALLEY.[1]

By Robert B. Miller, Forester,
Natural History Survey, Urbana, Ill.

Introduction.

I am very glad to have the privilege of addressing the Biology Section of the Central Association of Science and Mathematics Teachers on the subject of forestry.

It shows that you have rightly judged the place of forestry in placing it among the biological studies. The forester owes a debt of gratitude to the natural sciences, and especially the biological sciences, because these, along with certain engineering subjects, form the basis of his training. To illustrate, we have a subject in forestry called dendrology or biological dendrology as Dr. Fernow calls it, which means the life history of trees and forests. Not until the forester understands the life history of the trees he is dealing with, whether as individuals or in communities called "stands," can he be rated as a successful practitioner.

Again, the forester owes a debt of gratitude to the ecologist, because one of our basal subjects is silvics or to put it briefly, forest ecology, the ecology of woody plants. Ecology, as a branch of botany, deals with the relations of the plant to its environment—again a biological study. In fact, we segregate a certain group of these ecological factors and call them biotic factors, meaning those plant and animal agencies which help to make up habitat or environment.

So great is the importance of the animal life of the forest that some forestry schools are offering courses in forest zoology, this "being the study of all those forest animals, both wild and domestic, which are valuable for man to have in the forest. This includes the fish, game, forest food animals and birds, and also animals injurious to the forests." Such a course not only increases a man's pleasure in the woods but fits him for a study of problems in game preservation and conservation of wild life.

Taking the other side, may I venture to suggest that the teacher of biology, and especially of botany, might draw more largely from the forest as a source of interesting material? Special lessons along this line may be secured by writing the United States Forestry Service and a recent bulletin issued by W. R. Mattoon, Forestry Extension Specialist, suggests lessons from the home forest which may be worked out as projects by the students of

[1]Read before the Biology Section of the C. A. S. and M. T., November 26, 1920, at Englewood High School, Chicago.

agricultural high schools. This is a use of the forest which the teacher of biology should not overlook, while its use in civics, in physiography, and in geography is equally important. I am a firm believer in the introduction of simple forestry lessons in nature study in the grades, in the high schools and even in colleges and agricultural schools. Franklin B. Hough, Forestry Agent in the Department of Agriculture, as early as 1888, long before we had a Forest Service, had this idea in mind when he said:

"Every graduating class in a college should, at least, have the opportunity of hearing a few practical lectures upon forestry, and in several of our colleges, as at Dartmouth, instruction is now given in the classroom. In schools of less degree it would be a most profitable thing to inculcate ideas, if nothing more, as to the importance of our woodlands in the welfare of the country and the necessity of preventing injuries and avoiding waste."

Coming to the subject in hand, "Forestry in the Mississippi Valley," not until I began accumulating material about it did I realize its magnitude. So comprehensive was it that I have to a certain extent dodged the issue by securing from the different state foresters in the Middle West some representative lantern slides, and by means of these will attempt to show you the problems, programs, and opportunities for forestry in the Mississippi valley.

In considering such a subject, there is a question as to how far the Mississippi valley extends. We can hardly draw the line between valley and mountain forests, so intimately related are these two, nor tell how far the valley extends. We can only delimit it by picking out certain states which we think of as being in the Mississippi valley and especially those states which have sent representatives to this gathering. The main states to be spoken of will be then Minnesota, Michigan, Wisconsin, Ohio, Indiana and Illinois, Iowa and Nebraska, but these do not by any means constitute the entire area of the Mississippi valley where forestry is a vital problem. We should have to consider also Missouri, Arkansas, Tennessee and Kentucky, Mississippi, Louisiana, Texas, and Oklahoma.

If I remember my lectures on "forest regions" or "silvicultural regions" correctly, the region we are dealing with may be designated as the "Central Hardwood Forest," and a more limited portion of it may be called "the Central Woodlot Region," where most of the forest is in small holdings. The Central Hardwood

Forest, according to Van Hise, contained 280,000,000 acres and the timber was estimated at 1,400,000,000 feet. Now there are left only 130,000,000 acres, or about 46 per cent of the original area. The United States Forest Service says that there are 200,000,000 acres of farm woodlots in the United States and 142,000,000 acres are in the eastern United States, west of the Mississippi river. Roughly, this represents the area we are speaking about, the Central Woodlot region. Assuming that the annual growth is 45 cubic feet per year, this forest is furnishing about 71,500,000 cords of wood per year, with a value in 1909 of $170,000,000.

As the name indicates, it was the great hardwood forest of the Middle West. It was here that the finest white oak was sought by eastern wagon manufacturers, while tulip, ash, and black walnut abounded. In spite of depletion, it was this farm woodlot region which furnished its quota of wood for war purposes, the black walnut for gun stocks, the black locust for tree-nails used in ship building, the hickory for spokes and handles, the ash for the skids and longerons of airplanes. The forests of the Lake states may also be considered a part of the Mississippi valley forest, characterized by white, Norway and Jack pine and by the northern hardwoods, beech, birch, and maple. According to recent figures compiled by the Forest Service in connection with the Capper resolution, the original stand of pine in the Lake states has been reduced from 350,000,000,000 feet to about 8,000,000,000 feet so that the logging of pine in certain of these states is a thing of the past. The pine logger, in the march of progress has gone from the Lake states to the pineries of the South and finally to the Pacific Northwest, from whence our present supply of lumber is coming.

Let us briefly consider some of the conditions in the different states here represented, with their outstanding forestry problems, and we may well start with the Lake states. I have asked, in some cases, the state forester to give a condensed statement of his problems, and the slides will further bring out these points.

Wisconsin.

According to C. L. Harrington, of the Division of Forests and Parks, the state still has a large forest area and a stand of timber which has been estimated at about fifty billion feet. This is composed chiefly of mixed hardwoods and hemlock and is located for the most part in the northeastern counties. The remaining stands of white pine are very few in number and comparatively

limited in acreage. It has been estimated that there are approximately ten million acres of undeveloped land in the thirty northern counties of the state, of which close to two million acres, on account of being rough, rocky, or sandy, are primarily adapted to forestry purposes. The State Conservation Commission has charge of all activities pertaining to forest, fish, and game resources, and their biggest problem is concerned with fire protection on cut-over, sandy lands. It has been found that the trees native to Wisconsin vigorously assert themselves if given a fair chance.

Minnesota.

W. T. Cox, State Forester of Minnesota, has built up an efficient forestry service. The assistant forester is Dillon P. Tierney, who has been placed in direct charge of state forests. The new state forests created by an act of legislature in 1917 are being brought under administration. In a strip 40 miles wide and 100 miles long in St. Louis, Cook and Lake counties, there are 350,000 acres of state of rest, 1,250,000 acres of National Forest and 2,833,671 acres of private holdings.

Among the problems of Minnesota may be mentioned the forest fire problem, with the necessary supervision of more than 3,000 lumbering operations, the establishment of patrol along railroad lines to prevent forest fires, the inspection of railway locomotives, and looking after settlers' fires. Itasca State Park, which it is intended to increase to seven miles square, constitutes a tract for recreation and camping, for protection of game, and serves as a demonstration forest. Its administration with the keeping up of permanent improvements is no small task, as the number of tourists and campers attracted each year to Douglas Lodge and the cottages in the park is constantly increasing. Recreation and the pursuit of health is made one of the important uses of the forests of Minnesota. Another is their use as a supply of timber, with the constant supervision of cuttings to prevent disastrous forest fires such as have occurred in the state. The state has the benefit of cooperation under the Weeks law but the funds thus received, together with the state appropriations are entirely inadequate for the very large areas which must be protected, just as in the case of other states.

Michigan.

Michigan has as her main problems the protection of state and private lands against fire and the planting up of millions of acres

of burned over pine lands. The Public Domain Commission, Grayling, Michigan, has charge of forest conservation in the state, with Marcus Schaaf as State Forester. As the slides will show, Mr. Schaaf is developing an extensive forest nursery at Grayling, Michigan, raising and planting many seedlings every year with remarkable success and at the same time is perfecting methods of fire protection for these plantations and for the state lands. Michigan for many years had an acute tax land problem, many acres of lands reverting to the state because the owners had failed to pay the taxes upon them, some of them being cut over lands and burned lands. By recent legislation, 600,000 acres of forest land have been acquired by the Public Domain Commission through the reversion to it of these delinquent tax lands. By the law, lands on which the taxes have become delinquent for a certain period revert to the state and become automatically a part of the state forests. Michigan, just as many other states, has the question of land classification to deal with, many lands having been advertised as fine farming lands by land sharks on which it was impossible for the purchasers to make a living. As a result, many farms have been abandoned after unsuccessful attempts at farming. This emphasizes the need in every state of a separation of the soils into those suited for agricultural as distinguished from forest soils. In the future it seems probable that the United States Forest Service may be able to cooperate with the states in studies of land classification, this being a vital problem in all of these middle western states. This will only be carrying out Colonel Greeley's policy that "all idle land unsuited to agriculture should be devoted to forest crops until it is needed for farming."

IOWA.

In the state of Iowa, protection from fire is overshadowed by the necessity of planting for a future supply of timber, the establishment and improvement of farmer's woodlots and shelter belts. Prof. G. B. MacDonald is the forester at the Iowa State College of Agriculture and in his opinion Iowa is one of the states where Federal cooperation can best be used in the establishment and maintenance of nurseries so that planting stock can be distributed by the state at cost. Iowa is far ahead of many of the middle western states in her progressive policy for the establishment of state parks. The slides show the "Backbone" in Delaware county, a tract of 1,200 acres about which much has been written by botanists and geologists. Prof. MacDonald sums up

the need for state parks for Iowa in the following expressive way: "In conclusion it will seem that the state forest park area is desirable from many standpoints. Its aesthetic and recreational values cannot be questioned; its scientific value in the preservation of native flora will at least be appreciated by the people of the state. In addition, its value for the conservation of game birds and animals is easily recognized and its value from the business man's standpoint is readily apparent. The continuance of the state park program which has now been started, if extended to all parts of Iowa, will mark the beginning of a splendid period of development in this state, which will mean much not only to the people of today but to those of tomorrow."

Ohio, Indiana, and Illinois.

The best idea of forestry conditions in these three states can be secured by writing for a report of the Tri-State Forestry Conference held at Indianapolis, October 19, 1919, and we will not burden you with details which can be secured from the Indiana Board of Conservation. In all of the southern counties of these three states the keeping of timber on rough land unsuited to agriculture and liable to erosion when the protective cover of forest is removed is a vital internal problem. Such protection of slopes is more or less interwoven with the questions of fire protection and exclusion, at least in young timber, of grazing animals. Planting up of waste lands, stimulation of interest in timber growing by mining companies and the acquisition of suitable sites for public parks and state forests all come in for their share of attention.

Then there is the interest among the wood-using industries of these three states, occasioned by the fact that they are seriously alarmed about a supply of raw material for their factories. This culminated in the formation of a Council of Wood-Using Industries in Chicago on September 28. This council has the same relation toward the industries represented as the National Lumber Manufacturer's Association has to lumbermen and the American Pulp and Paper Association to the pulp men. These three great organizations, in conjunction with the Society of American Foresters and the United States Forest Service will insist, at the next session of Congress, upon an appropriation of at least one million dollars to be spent in cooperation with states who fall into line with the Federal forestry policy. Sixteen out of thirty-four foresters present at a meeting at Atlantic City on November 13 signified their willingness to support the program

of the Forest Service for making forest lands productive. Educators the country over, and especially teachers of biology, should back up their Senators and Representatives in insisting upon a carrying out of the national forestry program in cooperation with the states. I am glad to say that the states of the Mississippi valley are almost a unit in supporting Colonel Greeley's policy and that in the next few years we can look for remarkable advances toward forest conservation and renewal in the Central Hardwood region.

THE ANCIENT BACTERIA.

Bacteria are at once the simplest and the oldest of living things on our planet. Not so long ago, it was taught that the bacteria are degenerated relations of the green or blue-green algae, but the investigators of the earth crust find evidences of bacteria in the earliest strata that contain organic remains and now regard them as the original "old settlers." Finds of this nature seem to have pushed back the date of the origin of plants and animals for millions of years. The earliest bacteria appear to have obtained their energy by oxidizing substances other than those containing carbon. The sulphur and iron bacteria, which are undoubtedly responsible for some of our iron deposits are among the number. Some such forms have probably given rise to the higher species of plants that get their energy through photosynthesis. If we may judge from the evidence of the rocks, the early bacteria were not disease producing. Bacterial diseases have originated as evolution has progressed. The first animals and plants evidently were not confined to any definite length of life, but lived on in placid enjoyment of their environment until some change in the earth itself terminated their existence. Disease and death, due to it, appear to be mere modern adaptations.—[*American Botanist.*

RIDDING RANGES OF RODENTS AND PREDATORY ANIMALS.

The losses caused by predatory animals, prairie dogs, ground squirrels, and other similar rodent pests on the western ranges is estimated to be more than $300,000,000 annually. These animals and pests, according to the report, destroy live stock, crops, and range grass, and so seriously do they handicap the western farmer that the United States Department of Agriculture, in cooperation with the various States, has conducted a systematic campaign to destroy them and curtail the losses for which they a e responsible.

"The hunters in the service of the department," says the Secretary, "killed more than 25,000 predatory animals last year, and perhaps an equal number were destroyed by a poisoning campaign, resulting in a saving to the live-stock interests estimated at $6,000,000." It may be added that since the work was begun, in 1915, the skins of the animals destroyed have been sold and the net proceeds, aggregating more than $240,000, turned into the Treasury.—[*U. S. Dept. of Agriculture.*

LOCATION OF VIRTUAL IMAGES BY THE PARALLAX METHOD.

By Philo F. Hammond,

University of Wyoming, Laramie

Figure 1 represents the method commonly given in elementary textbooks for locating the image formed by a converging

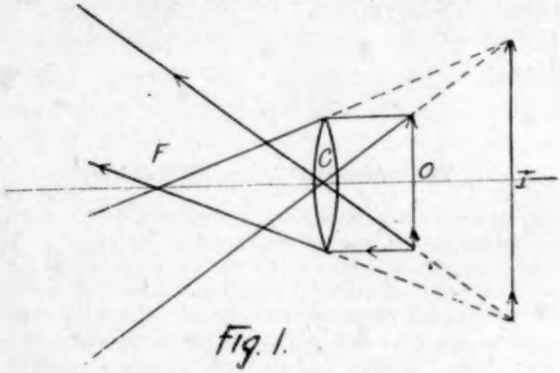


Fig. 1.

Vertical Section

lens of a line object by construction. If we consider a horizontal cross-section of this through the principal axis, we have the conditions for a point object on the principal axis (Fig. 2).

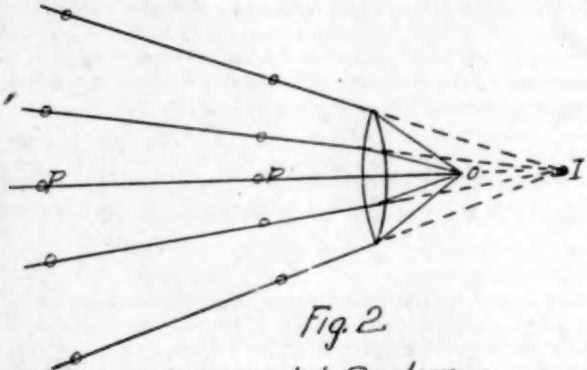


Fig. 2.

Horizontal Section.

Now if a light, wooden bar (B—Fig. 3) is mounted upon a stand of an optical bench (S) back of object (O) and adjusted so that S is in the position of the image O, it is evident from Figure 2 that no matter what the position of the bar, if moved about in a horizontal plane, hat pins (P and p) projecting through holes in the bar will always be in line with the image of O. The bar should be supported by a horizontal rod (R) which may

be mounted upon a stand placed at one side of the optical bench.

In practice it is sometimes more convenient to set the stand (S) and adjust the pin representing the object.

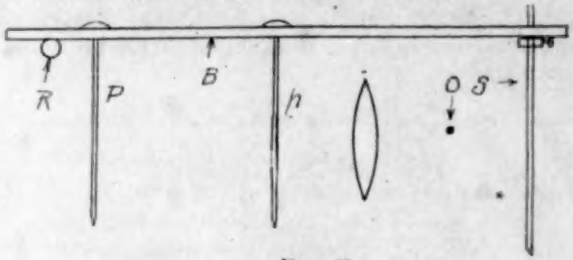


Fig. 3.
Vertical Section.

This method has been found to give good results with medium sized lenses of fair quality—nearly as good as the same lenses give for real images by the parallax method. With the concave mirrors at our disposal, however, the results were not satisfactory.[1] The greatest difficulty with the cheaper grades of lenses and mirrors is that the focal length is not the same for both sides, due to the irregularities of their surfaces.

THE USES OF HELIUM.

The production of helium on an extensive scale which began during the war, when it was proposed to use this gas for filling belloons and dirigibles, has led to considerable discussion as to other ways in which helium can be used. Prof. J. C. McLennan deals at length with this question in a lecture, published in *Nature*. It appears, in the first place, that if helium is used for filling airships the supply from the British Empire would be far from adequate for the British air fleet. One way of economizing it, would be to use it only in compartments adjacent to the engines. As to various industrial uses, it may be used as a filling for thermionic amplifying valves of the ionization type; also for filling tungsten incandescent lamps, especially for signal purposes where rapid dimming is essential, and for producing gas arc lamps in which tungsten terminals are used. Some objections to these uses are pointed out. Nutting has shown that Geissler tubes filled with helium are very suitable, under certain conditions, for light standards in spectrophotometry. Helium is also invaluable in spectroscopy, and for various other laboratory uses. Elihu Thomson has suggested that if divers were supplied with a mixture of oxygen and helium, the rate of expulsion of carbon dioxide from the lungs might be increased, and thus the period of submergence might be considerably lengthened. The widest application of helium, however, appears to be in the field of low temperature research, as liquid helium—and perhaps eventually solid helium—enables one to reach the lowest temperatures attainable by an means. A point of special importance to which Professor McLennan calls attention is that the supplies of natural gas from which helium can be extracted are being rapidly used up; hence it might be well to store a supply of this gas for use in years to come.—[*Scientific American.*

[1]This method was first used by the writer last year at the North Dakota Agricultural College.

HIGHEST ELEVATIONS ON PRINCIPAL WESTERN RAILROADS.

Many health seekers who are preparing to make trips from the East to the West write to the United States Geological Survey, Department of the Interior, for information regarding the highest points on transcontinental railroad lines, so that they may avoid going above certain altitudes. In order to answer such inquiries the following list has been complied from various sources:

Highest points on principal western railroads.

Route.	Between—	Elevation (feet)	Nearest station.	State.
Atchison, Topeka & Santa Fe.	Kansas City, Mo., and Denver, Colo.	7,225	Palmer Lake	Colorado.
	Kansas City, Mo., and San Francisco, Calif.	7,625	Lynn	New Mexico
	Kansas City, Mo., and Albuquerque, N. Mex., via Amarillo, Tex.	6,499	Mountainair	Do.
	Albuquerque, N. Mex., and San Francisco, Calif.	7,313	Riordon	Arizona
Chicago, Milwaukee & St. Paul.	Chicago, Ill., and Seattle, Wash.	6,322	Donald	Montana
Chicago, Burlington & Quincy	Omaha, Nebr., and Billings, Mont.	4,747	Sparta	Wyoming
Denver & Rio Grande	Denver, Colo., and Salt Lake City, Utah:			
	Via Leadville, Colo	10,219	Tennessee Pass	Colorado
	Via Gunnison, Colo	10,846	Marshall Pass	Do.
	Via Durango, Colo	10,238	Lizzard Head	Do.
El Paso & Southwestern	Santa Rosa, N. Mex., and El Paso, Tex.	5,040	Los Tanos	New Mexico
	El Paso, Tex., and Tucson, Ariz.	4,746	Continental Divide, near Hachita	Do.
Great Northern	St. Paul, Minn., and Seattle, Wash.	5,215	Summit	Montana
	St. Paul, Minn., and Butte, Mont.	6,380	Elk Park Pass	Do.
Los Angeles & Salt Lake	Los Angeles, Calif., and Salt Lake City, Utah:			
	Via Tintic, Utah	6,033	Boulder	Utah
	Via Provo, Utah	5,225	Sharps Siding	Do.
Northern Pacific	St. Paul, Minn., & Seattle, Wash:			
	Via Helena, Mont	5,573	Blossburg	Do.
	Via Butte, Mont	6,334	Homestake	Do.
Oregon Short Line	Granger, Wyo., and Butte, Mont.	6,908	Kemmerer	Wyoming
	Granger, Wyo., and Portland Oreg.	6,908	Do.	Do.
Rock Island	Chicago, Ill., and Colorado Springs, Colo.	6,899	Tiptop	Colorado
	Chicago, Ill., and Santa Rosa N. Mex.	4,190	Bravo	Texas
San Diego & Arizona	San Diego and Calexico, Calif	3,660	Hipass	California
Southern Pacific	Ogden, Utah, and Sacramento, Calif.	7,012	Donner Pass	Do.
	New Orleans, La., & El Paso, Tex.	5,100	Alpine	Texas
	El Paso, Tex., and San Francisco or Los Angeles, Calif	4,614	Dragoon	Arizona
Texas Pacific	Fort Worth & El Paso, Tex	4,550	Allamore	Texas
Union Pacific	St. Louis, Mo., & Denver Col.	5,516	Watkins	Colorado
	Omaha, Nebr., and Ogden, Utah	8,006	Sherman	Wyoming
Western Pacific	Salt Lake City, Utah and San Francisco, Calif	5,907	Flower Lake Tunnel	Nevada

ENORMOUS RAINFALL IN HAWAII.

An inch a day is the average rainfall in the upper Waipio Valley, Hawaii, which makes it one of the areas in the world where the rainfall is heaviest. On the other hand, the rainfall on some of the slopes of Hualalai, on the same island, is only 20 inches a year. The only surface streams on the island are along the northeast coast between Hilo and Kohala. Waipio River, according to the United States Geological Survey, has been partly developed for irrigation.

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg,

Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1044 E. Marquette Road, Chicago.

SOLUTION OF PROBLEMS.

666. *Proposed by Daniel Kreth, Wellman, Ia.*

Show that when n is any prime number, $(x-1)^n$ and x^n-1 will have the same remainder when divided by n.

Solution by DeWitt T. Weaver, Sistersville, W. Va.

Expanding by the binomial formula,

$$(x-1)^n = x^n - nx^{n-1} + [n(n-1)/1\cdot 2]x^{n-2} - [n(n-1)(n-2)/1\cdot 2\cdot 3]x^{n-3} + \cdot\ \cdot\ \cdot\ \cdot\ \cdot\ -1$$

Since n is prime, it is an odd intiger and the last term must be -1; also it must be a factor of the coefficient of every term of the expansion other than the first and last terms. Hence

$$(x-1)^n = x^n - 1 + n(\text{some integer}).$$

Then when $(x-1)^n$ is divided by n, any remainder that may arise must come from the result of dividing the term x^n-1 by n.

The only prime number not odd is $n = 2$. But the result is still true, for if x is odd, then $(x-1)^n$ and x^n-1 are divisible by 2 and if x is even the remainder is 1.

Also solved by N. Barotz, New York City, Fred A. Lewis, University, Ala., and Prof. Tudor, State College, Pa.

667. *Proposed by Abigail Glenn, Student, Chicago Normal College.*

Through three given points in the same straight line, construct three lines which shall form a triangle inscribed in a given circle.

No solution has been received for this problem.

668. *Proposed by A. Pelletier, Ecole Polytechnique, Montreal, Can.*

Prove that the diameter AD of the circle circumscribing the triangle ABC is divided by BC in the ratio tanB · tanC : 1.

Solution by Fred A. Lewis, University, Ala.

Let AD intersect BC in E, and $\angle CAD = \angle CBD = \angle \alpha$. Then, by the law of sines, in $\triangle ABP$,

$$AP/\sin B = BP/\sin(A-\alpha)$$

and in $\triangle APC$,

$$AP/\sin C = CP/\sin \alpha$$

Hence,

$$AP^2/\sin B \sin C = BP \cdot CP/\sin(A-\alpha)\sin\alpha = AP \cdot PD\sin(A-\alpha)\sin\alpha.$$

or $\quad AP/PD = \sin B \sin C/\sin(A-\alpha)\sin\alpha.$

But $B+\alpha = 90$, so that $\sin\alpha = \cos B$; and $\sin(A-\alpha) = \cos C$. Hence

$$AP/PD = \tan B \tan C.$$

Also solved by N. Barotz, New York City, W. R. Warne, Pennsylvania State College, State College, Pa., H. C. Whitaker, Philadelphia.

669. *Proposed by Herbert C. Whitaker, Philadelphia.*

At a certain time, a train overtakes a man, A, and 10 seconds thereafter, passes him. The train overtakes another man, B, 20 minutes after passing A, and 9 seconds thereafter passes B. Counting from the time the train passed B, how soon will the two men meet?

I. *Solution by N. Barotz, New York City.*

Let l = length of the train, r = rate of the train per second, m = A's rate, and n = B's rate. Since the train passes A in 10 seconds, and B in 9 seconds,

(1) $$10r-10m = l$$

(2) $$9r-9n = l.$$

At the moment when the train has passed B, A is $1219m$ from its starting point, and the train is $1219r$ from the same starting point; and, since B is at the end of the train, B is $1219r-l$ from the starting point. Hence, the distance between A and B is $d = 1219r-l-1219m$. Substituting the value of l from (1) in this expression, we get

(3) $$d = 1209r-1209m$$

Subtracting (2) from (1) gives $r = 10m-9n$; and putting this value of r in (3) gives $d = 10881m-10881n$.

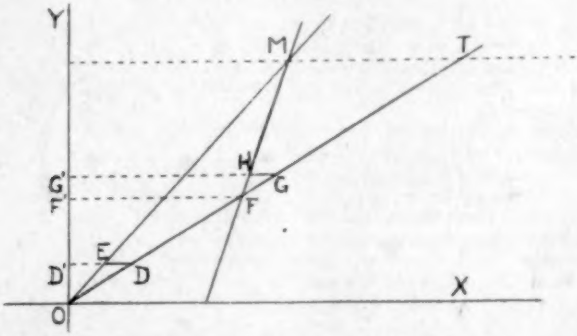
The time required for the men to meet is $d/(m-n)$ or 10881 seconds or 3 hrs. 1 min. 21 secs.

Also solved by Michael Goldberg, Philadelphia, Pa. Several solutions were incorrect due to assuming that A's rate was nine tenths of B's rate. From the above equations we can see that this would be true only if $r = 0$, that is, if the train was not in motion. *The following two solutions by the Proposer* are of interest.

II. Let a be the interval of time while the train passes the first man, b the interval in going to the second man, c the interval in passing the second man, and y be the required time. m, n, l, and d are used as above. Then equations (1) and (2) are $l = a(r-m) = c(r-n)$. After the train passes the second man, the position of the first man, counted from the time when the front of the train overtook him is $(a+b+c)m$; and the position of the second man is $(a+b+c)r-l$ or $(a+b)r+cn$. From this expression we eliminate r by using $r = (am-cn)/(a-c)$; then subtracting the two positions, the distance apart of the two men is

$$c(b+c)(m-n)/(a-c).$$

Hence the desired time is $y = c(b+c)/(a-c)$.



III. The figure represents a train dispatcher's diagram. Intervals of time are laid off along OY, and distances along OX. $OD' = a$, $D'F' = b$, $F'G' = c$. The line OT represents the progress of the train. From D and G lay off horizontal lines equal to the length of the train, thereby fixing points E and H. Extend OE and FH until they meet, at M. Drawing horizontal and vertical lines through M, we find at what time and after what distance the men will meet. $\triangle OED$ is similar to $\triangle OMT$; and $\triangle FHG$ is similar to $\triangle FMT$. Hence $OM/OE = MT/l = FM/FH$, and their projections are proportioned, or $(a+b+c+y)/a = (c+y)/c$, or $y = c(b+c)/(a-c)$.

670. *Proposed by Herbert C. Whitaker, Philadelphia, Pa.*

What will be the radius of five equal circles which will be tangent to a circle, whose radius is 12 inches, and also tangent to one another.

This is the first of the problems proposed for students in the high schools, as announced in the October, 1920, issue. There are two solutions, according to whether the five circles are circumscribed or inscribed in the given circle. Using trigonometry we get for the circumscribed circles $r/(r+12) = \sin 36°$ or $r = 17.112$, and for the inscribed circles $r/(12-r) = \sin 36°$ or $r = 4.442$. By geometry the first of these can be found, but not the second. The only student to send in the two solutions was *M. Buchman*, but unfortunately his arithmetical work was inexact. Taking all things into consideration, the editor has ranked the solutions in the following order:

Mildred M. Hunt, Lewis and Clark H. S., Spokane, Wash.; Milton Kauffman, Wendell Phillips H. S., Chicago; Forest Young, Redlands H. S., Calif.; Moe Buchman, Brooklyn Boys' H. S., Brooklyn; Walter Powers, Herman Merker, and Edward Wheeler, Nicholas Senn H. S., Chicago.

I. *Solution by Mildred M. Hunt.*

The side of a decagon inscribed in a circle is found by dividing the radius into mean and extreme ratio. We find this is $y = 7.416$ by solving the equation $12/y = y/(12-y)$. Considering the triangle (one tenth of the decagon) with sides 12, 12, y, we can find its altitude to the side 12 by first finding its area. The altitude $= 7.053 = a$. Then from the similar triangles in the complete figure, we get $12/7.053 = (12+x)/x$ where x is the desired radius.

II. *Solution by Milton Kauffman.*

The work is the same as the above, but radicals are used until the final step is reached. $y = 6\sqrt{5}-6$. And using right triangles instead of the area to find the altitude, we get $a = 3[10-2\sqrt{5}]^{\frac{1}{2}}$, and then compute x as before.

PROBLEMS FOR SOLUTION.

681. *Proposed by W. R. Warne, Pennsylvania State College, State College, Pa.*

ABC is a right triangle with the right angle at C. E is a point on AB, and D is a point on CB. ED is parallel to AC. CD = 10, DE = 15, and CB+BA = 100. Find the lengths of all the various lines in the figure.

682. *Proposed by T. E. N. Eaton, Redlands High School, Calif.*

Solve the two equations

$$R\cos\alpha + R\alpha\sin\alpha = 5.875$$
$$R\sin\alpha - R\alpha\cos\alpha = .72$$

683. *Proposed by N. Anning, Ann Arbor, Mich.*

Find the nth term of the series 1, 2, 7, 11, 19, 26, 37.

684. *Proposed by F. A. Cadwell, St. Paul, Minn.*

In *Wentworth & Smith's Plane Geometry*, problem 5, page 142, reads:

"To construct a triangle having given one side, an adjacent angle and the difference of the other sides."

This is stated as though the size of the given angle was immaterial, but in the figure given to show how the construction is made the angle given is the lesser of the two angles adjacent to the given side.

In *Wells "Essentials of Geometry"* No. 55, page 226, reads:

"Given the base of a triangle, an adjacent *acute* angle and the difference of the other two sides, to construct the triangle."

Here, again, in the figure given to show the construction the angle given is the smaller of the two angles adjacent to the given side.

Hence, the following is proposed:

Construct a triangle having given the base, the difference of the other two sides and the greater angle adjacent to the base.

685. *For Undergraduates. See problem 670 above. Proposed by M. D. Taylor, Scott High School, Toledo, Ohio.*

Inscribe a square in a quadrant of a circle so that the diagonals of the square will be perpendicular to the two radii of the quadrant; also find the area of the square if the radius is r.

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Examination and Test Papers.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

Send in any tests you are trying. Others will be interested in what you are doing.

State teachers' examination papers and State examination papers for pupils are also much desired. What States have such examinations? Please inform the Editor how and where they may be obtained.

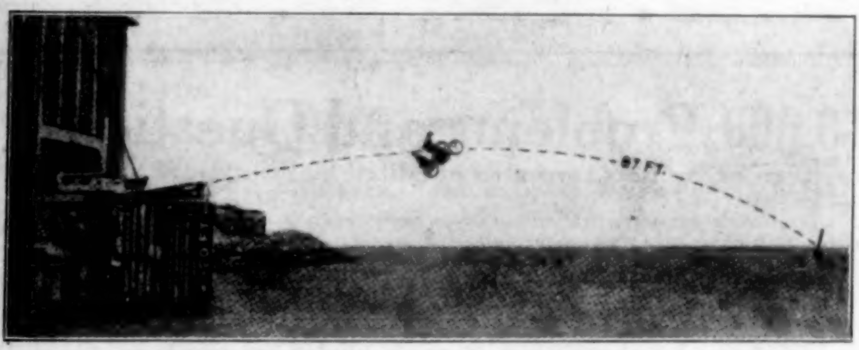
Acknowledgment.

Miss Pearl M. Martin, Biwabik, Minnesota, has sent in Minnesota State Board Examinations in General Science, Physics, Algebra and Geometry. The General Science paper is the first given by the Board. It is published below.

QUESTIONS AND PROBLEMS FOR SOLUTION.

355. *Proposed by K. L. Pohlman, Cleveland, Ohio.*

Popular Mechanics published the picture shown below.



Suppose the weight of the man and motorcycle to be 350 lbs. What was the resisting force of the air measured in pounds?

356. *Submitted by Pearl M. Martin, Biwabik, Minn.*

MINNESOTA STATE BOARD EXAMINATIONS

May, 1920.

Answer questions in the order given. Put down the number of the question and its credits whether you answer it or not. The time for writing this examination is two hours.

GENERAL SCIENCE

Monday, May 24, 1920, 2:00 p. m.

Answer any five.

I. (20) Define any ten:

1. Caloric.	11. Gravity.
2. Element.	12. Embryo.
3. Distillation.	13. Vertebrate.
4. Mammal.	14. Electrolysis.

5.	Parasite.	15.	Toxin.
6.	Siphon.	16.	Pasteurized milk.
7.	Stamen.	17.	Lodestone.
8.	Pollination.	18.	Atom.
9.	Seed.	19.	Molecule.
10.	Spore.	20.	Vacuum.

II. (20) 1. For what is a thermometer used?
2. Name two kinds of thermometers.
3. In what three states does water exist according to its temperature?
4. Why is a hot water system excellent for heating a schoolhouse?
5. What prevents heat from escaping through the space between the walls of a fireless cooker?

III. (20) 1. What is a partial vacuum?
2. Why does not the manufacturer remove all the air from an electric light bulb before it is sealed at the factory?
3. What makes water rise in a siphon or pump?
4. Why is it a poor plan to leave an automobile with tires pumped up standing in a hot sun?

IV. (20) 1. Which gas in the air makes fire burn?
2. Which gas in the air is necessary for breathing?
3. How does a fish get oxygen to breathe?
4. If a sleeping room contains a stove, why should a window be left open at night?
5. If a candle lowered into an old well "goes out," what does that indicate as to the condition of the air?

V. (20) 1. Why should dishes used by an invalid be washed in boiling water?
2. Why should the lids on fruit jars be screwed down as soon as they are removed from the boiler?
3. Why should you not put your neighbor's pencil into your mouth?
4. Why should furniture be dusted with an oiled cloth?
5. Why is bread wrapped in waxed paper?

VI. (20) Tell what two of the following scientists have done to help mankind:

Edison	Pasteur	Madame Curie
Mendel	Darwin	Burbank

VII. (20) New York and St. Louis have just had enormous fur auctions. Is the number of wild fur-bearing animals in Minnesota increasing? Give reason for your reply.
How does the price of pelts compare with the price of five years ago?
As skunk pelts are valuable, why does the United States government ask that skunks shall not be killed?
There is a new "silver fox" farm at Lake Pepin. Why have several fox farms been started in Minnesota?

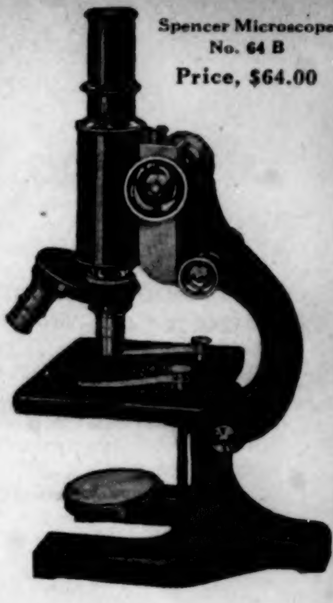
VIII. (20) 1. How many poles has a magnet?
2. Where is the north magnetic pole of the earth?
3. By what process does a nail near a magnet become magnetized without touching the magnet?
4. Name a good conductor of electricity.
5. Name a good non-conductor or insulator.

(What do you think of examinations in General Science?)

SOLUTIONS AND ANSWERS.

347. *Proposed by K. L. Pohlman, Cleveland, Ohio.*

A hammer weighing 2 pounds has a velocity of 12 feet per second at the instant it strikes the head of a nail. Find the force which the hammer exerts on the nail if it is driven into the wood 1/4 of an inch.



Solution by A. Haven Smith, Redlands, Cal.
Kinetic Energy

$$FS = WV^2/2g$$
$$S = 1/48 \text{ ft.}, \quad W = 2 \text{ pounds}, \quad V = 12 \text{ ft.}$$
$$F(1/48) = [2(12)^2]/[2(32)]$$
$$F = 216 \text{ pounds.}$$

MOUNT MITCHELL NEARLY 7,000 FEET HIGH.

Many people believe that Mount Washington, in New Hampshire, is the highest mountain in the eastern part of the United States. Mount Washington stands 6,293 feet above sea level, according to the United States Geological Survey, Department of the Interior, but many peaks in the Southern Appalachians are several hundred feet higher than New Hampshire's famous mountain. The highest mountain in the Appalachian system—the highest point in the United States east of the Rockies—is Mount Mitchell, in North Carolina, which stands at an elevation of 6,711 feet. The highest mountain in Tennessee, Mount Guyot, stands 6,636 feet above sea level.

CONTROLLING INSECT PESTS.

The work of controlling insect outbreaks has presented many difficult and complex problems to the United States Department of Agriculture, declares the Secretary in his annual report. As an illustration the Secretary refers to the fight with the pink bollworm, which experts in this and other countries regard as probably the most destructive pest of cotton. The task of exterminating this pest, begun by the department in 1917, gave promise of success; but, according to the report, a new and serious situation has been presented by the discovery of the insect in a district in Louisiana not heretofore known to be infested and by its reappearance in southeastern Texas.

"The efforts to eradicate the pest are being prosecuted as vigorously as possible," says the Secretary, "but they are necessarily handicapped by the failure of the State of Texas to establish and enforce noncotton zones in the infested areas. Whether eradication can be accomplished in the circumstances is problematical, but, nevertheless, no steps should be omitted to prevent the additional drain on the South's most important money crop which the spread of the pink bollworm to other sections of the cotton belt would involve.

"The boll weevil, also, causes enormous damage to the cotton crop. But the department's experts, after many years of painstaking experiments, have now found a successful method of controlling the pest by dusting the plants with calcium arsenate. As a result, the manufacture and sale of this product has reached very large proportions. Through its enforcement of the insecticide and fungicide act, the purpose of which is to insure a high standard of purity and efficiency in insecticides and fungicides used in combating plant diseases and insects, the department is keeping off the market a great many tons of calcium arsenate of poor grade which, if used, not only would fail to control the boll weevil but would seriously damage the cotton plants."—[*U. S. Dept. of Agriculture.*

ARTICLES IN CURRENT PERIODICALS

American Botanist for November; *Joliet, Illinois; $1.50 per year,* 40 *cents a copy:* "Plant Names and Their Meaning" (I), Willard N. Clute; "Christmas Roses," Mary E. Hardy; "The Rosiest American Plant," Willard N. Clute; "New England in Autumn," Manley B. Townsend.

American Journal of Botany, for November; *Brooklyn Botanic Garden, Brooklyn, N. Y.:* "The Cambium and Its Derivative Tissues," "II.

Size Variations of Cambial Initials in Gymnosperms and Angiosperms," I. W. Bailey; "An Apparatus for Determining Small Amounts of Carbon Dioxide," R. C. Wright; "The Secretion of Invertase by Plant Roots," L. Knudson; "Daily Rhythms of Elongation and Cell Division in Certain Roots," Ray C. Friesner.

American Mathematical Monthly, for November; *Lancaster, Penn.;* $5.00 *per year*, 60 *cents a copy:* "The Fifth Summer Meeting of the Association," W. D. Cairns; "The Danger Area Curve," A. S. Merrill; "Expressions for Certain Accelerations of a Particle," Dr. G. H. Cresse. Questions and Discussions: Questions—Replies to Question 34, D. C. Gillespie; Discussions—"The Mathematics of Biometry," L. J. Reed; "Complex Numbers in Advanced Algebra," H. E. Webb; "On Proofs by Mathematical Induction," E. T. Bell; "A Practical Printer's Problem in Maxima and Minima," E. E. DeCou.

Geographical Review, for December; *Broadway, at 156th Street, New York City;* $5.00 *per year*, 50 *cents a copy:* "Some Types of Cities in Temperate Europe," H. J. Fleure (10 maps, 5 views). "The Black Belt of Alabama," Herdman F. Cleland (2 maps, 1 diagram, 7 photos). "Arrival and Departure of Winter Conditions in the Mackenzie River Basin," E. M. Kindle (1 map, 5 photos). "The Origin of Lake Athabaska," F. J. Alcock (2 maps, 6 photos). "The New Frontiers of Hungary" (1 insert map).

Journal of Geography, for November; *Menasha, Wis.;* $2.00 *per year*, 25 *cents a copy:* "Geographic Influences in the Settlement of Black Prairie in Texas," Harriet Smith; "A Course in Geography for Normal Schools," Bessie L. Ashton; "Power and Iron in France," and "The Geography of a Country," E. E. Lackey; "The New Boundaries of Bulgaria."

Nature Study Review, for November; *Ithaca, N. Y.;* $1.50 *per year*, 20 *cents a copy:* "The Largest Beetle in North America," Dr. R. W. Shufeldt; "Clover," Adeline M. Wenger; "The Tree Shells of Hawaii," Vaughn MacCaughey; "A Seven-Year-Old Ornithologist," E. D. Everdell; "The Fresh Water Pearl Makers," Dr. N. M. Grier; "The Robin Junior Audubon Society," M. B. Birkicht; "The Pine Tree and the Man in the Moon," Jay Traver; "The White Pine," M. F. Lumsden.

National Geographic Magazine, for December; *Washington, D. C.;* $4.00 *per year*, 50 *cents a copy:* "Falconry, the Sport of Kings" (23 illustrations), Louis A. Fuertes; "American Birds of Prey—A Review of Their Value" (6 illustrations), Louis A. Fuertes; "A Little-Known Marvel of the Western Hemisphere" (13 illustrations), G. H. Osterhout, Jr.; "Haiti, the Home of Twin Republics" (12 illustrations), Sir Harry Johnston; "Haiti and Its Regeneration" (10 illustrations), "Glimpses of Siberia—Russia's 'Wild East'" (26 illustrations), Cody Marsh.

Photo-Era, for November; *Boston, Mass.;* $2.50 *per year*, 25 *cents a copy:* "Traveling with a Camera," O. C. Gould; "Tank-Philosophy," E. C. L. Morse; "The Printing-Box Up-to-date," E. S. Anderson; "Auramine as a Sensitiser," O. Bloch and F. F. Renwick; "Brilliant Contrasty Prints from Flat Negatives," E. B. Whiting; "An Efficient Negative-Washer," Winn W. Davidson; "Why Deposits Occur in Photographic Solutions," The British Journal; "A Photographer and a Goat-Ranch," Lillian E. Davis; "A Simple Experiment in Night-Photography," A. H. Beardsley.

Physical Review, for November; *Ithaca, N. Y.* $7.00 *per year*, 75 *cents a copy:* "Arcing Voltages in Mercury Vapor as a Function of the Temperature of a Cathode," T. C. Hebb; "The Calculation of Detecting and Amplifying Properties of an Electron Tube from its Static Characteristics," G. Breit; "The Detecting Efficiency of the Single Electron Tubes," E. O. Hulburt and G. Breit; "Variation with Pressure of the Residual Ionization Due to the Penetrating Radiation," K. Melvina Downey; "The Kinetic Theory of Magnetism," Warren Weaver; "A Photographic Method of Finding the Instantaneous Velocity of Spark Waves," Arthur L. Foley; "Is the Atom the Ultimate Magnetic Particle?" Arthur H. Compton and Oswald Rognley; "On the Free Oscillations of

Spheroids," Rajendra Nath Ghosh; "Soft X-Rays, A Note of Interpretation," H. M. Dadourian; "Velocity of Sound from a Moving Source," R. B. Abbott and J. W. Cook.

Popular Science Monthly, for December; *New York City; $3.00 per year, 25 cents a copy:* "Five Miles High in a Tank," Walter Bannard; "How the Big Searchlights are Tested;" "The Man of the Best Way," F. C. Kelly; "Over the Rockies in a Waterfall;" "Thirteen Billion Suns—Living and Dead," Abbe T. Moreux.

School Review, for December; *University of Chicago Press; $2.50 per year, 30 cents a copy:* "The Objectives of Secondary Education," Franklin Bobbitt; "Which Do We Want—Economy or Competence?" W. Randolph Burgess; "Determining Aims of Art Instruction for the Secondary School," William G. Whitford; "Chicago Intelligence Test in Harrison Technical High School," O. Winter; "An Evaluation of Exercises in Civics Textbooks," Thomas D. Brooks.

Scientific Monthly, for December; *Lancaster, Penn.; $5.00 per year, 50 cents a copy:* "At Timber-Line in the Land of Tahosa," Raymond J. Pool; "The Social Need for Scientific Psychology," Knight Dunlap; "Joseph Lister, His Life and Work," Dr. Paul F. Clark; "Food Tastes and Food Prejudices of Men and Dogs," Vilhjalmur Stefansson; "The Scientific Selection of Men," Arthur Frank Payne; "The Art of Writing Scientific Reports," F. H. Norton; "The Essential Characteristics of United States Climates," R. DeC. Ward.

BOOKS RECEIVED.

States in Minor Folds, by Charles E. Decker, University of Chicago. Pages ix+89. 17½x24½ cm. Cloth, 1920. $1.65. University of Chicago Press.

Annual Report of the Smithsonian Institution. Pages xii+612. 15½x23½ cm. Cloth. 1918. 75 cents. Government Printing Office, Washington.

The Early Embryology of the Chick, by Bradley M. Patten, Western Reserve University. 55 illustrations, 182 figures. Pages 1x+167. Cloth. 1920. 16x24 cm. P. Blakiston's Son & Co., Philadelphia.

Pastoral and Agricultural Botany, by John W. Harshberger, University of Pennsylvania. 121 illustrations. Pages xiii+294. Cloth. 1920. 14x20 cm. P. Blakiston's Son & Co., Philadelphia.

Common Science, by Carleton W. Washburne, Superintendent of Schools, Winnetka, Ill. 14x19 cm. Cloth. 1920. $1.60. World Book Company, Yonker-on-Hudson, N. Y.

Guide to Mineral Collections in the Illinois State Museum, by A. R. Crook, Director of Museum. Pages xxi+294. 16x23 cm. Cloth. 1920. State Museum, Springfield, Ill.

A Laboratory Manual of Anthropometry, by Davis H. Wilder, Smith College. Pages xi+193. 16x24 cm. Cloth. 1920. P. Blakiston's Son and Co., Philadelphia.

The Airplane, by Frederick Bedell, Cornell University. 257 pages. 15.5x23 cm. Cloth. 1920. $3. D. Van Nostrand Company, New York City.

Army Lessons in English, by Captain Garry C. Myers, Sanitary Corps, Director of Education. Books I and VI and Military Stories. 24 pages each. 15x22.5 cm. Paper. Recruit Educational Center, Camp Upton, N. Y.

Balopticons and Accessories. 99 pages. 16x24.5 cm. Paper. 1920. Bausch and Lomb Optical Co., Rochester, N. Y.

Year Book of the American Physical Society, D. C. Miller, Secretary Case School of Applied Science, Cleveland, Ohio. 83 pages. Paper. 1920. Case School, Cleveland, Ohio.

Back numbers of School Science, School Mathematics, and School Science and Mathematics may be had for 30 cents a single copy. The Mathematical Supplements for 15 cents a copy.

In sets the prices are, postpaid:

School Mathematics and Supplements, Vol. I, five numbers	$1.00
School Science, Vol. I, eight numbers	6.00
School Science, Vols. II and III, each	6.00
School Science, Vol. IV, three numbers	.75
School Science and Mathematics, Vols. V, VI, VII, VIII, IX X, XI, XII, XIII, XIV, XV, XVI and XVII, each	2.00
School Science and Mathematics, Vols. XVIII, XIX and XX each	2.50

Scientific Instruments and Laboratory Supplies. 240 pages. 18x25 cm. Paper. 1920. Standard Scientific Company, 147-153 Waverly Place, New York.

Geometry Review Book, by Murray J. Leventhal, Stuyvesant High School, New York City, and M. Weiner, New Utrecht High School, Brooklyn. 86 pages. 15x23 cm. Cloth. 1920. Review Book Co., 175 Fifth Ave., New York City.

The Regent's Questions in Physics and in Chemistry. 112 pages, physics; 96 pages chemistry. 13.5x17 cm. each. Paper 1920. Physics, 60 cents. Regents Publishing Co., 32 Union Square, New York.

Laboratory Experiments in Organic Chemistry, by E. P. Cook, Smith College. Pages ix+83. 12.5x18.5 cm. Cloth. 1920. $1. P. Blakiston's Sons and Co., Philadelphia.

Department of the Interior, Bureau of Education, the following Bulletins:

1920, No. 8, Agricultural and Mechanical Colleges, by Walton C. John.

1920, No. 10, Correspondence Study in Universities and Colleges, by Arthur J. Kline

1920, No. 26, Reorganization of Science in Secondary Schools, by the Commission of 47, through the Chairman, Otis W. Caldwell.

1920, No. 28, Monthly Record of Current Educational Publications. Index.

1919, No. 47, Private Commercial and Business Schools, 1917-18, by H. R. Bonner.

1919, No. 73, Nurse Training Schools, 1917-18, by direction of H. R. Bonner.

1919, No. 81, Statistics of Normal Schools, 1917-18, by L. E. Blanch and H. R. Bonner.

1919, No. 84, The University Extension Movement, by W. S. Bittner.

1919, No. 85, Development of Agricultural Instruction in Secondary Schools, by H. P. Barrows.

1920, No. 29, The National Crisis in Education: An Appeal to the People, by William T. Bowden.

1919, No. 65, The Eyesight of School Children, by J. H. Berkowitz.

College Entrance Examination Board, Twentieth Annual Report of the Secretary by Thomas S. Fiske, Secretary.

1920, No. 20, Salaries in Universities and Colleges in 1920.

Illustrated Mathematical Talks by Pupils of the Lincoln School, New York City. 44 pages. 15x23 cm. 34 illustrations. Paper. 1920. The Lincoln School, New York City.

Health Training for Teachers, Department of the Interior, Bulletin No. 8. 5 cents a copy. Superintendent of Documents, Government Printing Office, Washington, D. C.

Bulletin, No. 7, 1920, Requirements for the Bachelor's Degree, by Walton C. John, Bureau of Education. 311 pages. 15x23 cm. Paper. 1920. 35 cents. Government Printing Office, Washington, D. C.

Hamilton's Essentials of Arithmetic, by Samuel Hamilton, Superintendent of Schools, Allegheny Company, Pa. Lower grades, middle grades, higher grades. 224+xiv, 288+xxiii, 320+xix pages. 13.5x18 cm. Cloth. 1920. American Book Company, Chicago.

New Champion Spelling Book, by Warren E. Hicks, Cleveland, Ohio. 248 pages. 13x19 cm. Cloth. 1920, American Book Company, Chicago.

A Second Book in Algebra, by Fletcher Darrell, Lawrenceville School, and E. E. Arnold, Supreintendent Schools, Pelhams, N. Y. Pages v+330. 12.5x19 cm. Cloth. 1920. Charles E. Merrill Company, Chicago.

With the Doughboy in France, by Edward Hungerford. 291 pages. 13.5x19.5 cm. Cloth. 1920. $2. The Macmillan Co., New York City.

The Story of the American Red Cross in Italy, by Charles M. Bakewell. 253 pages. 13.5x19.5 cm. Cloth. 1920. The Macmillan Co., New York City.

The Passing Legions, by George B. Fife. 369 pages. 13.5x19.5 cm. Cloth. 1920. The Macmillan Co., New York City.

BOOK REVIEWS.

Guide to the Mineral Collections in the Illinois State Museum, by A. R. Crook, curator. Pages xxi+294. 15½x22½ cms. Cloth. Museum. Springfield, Illinois.

This is, without question, the most complete volume that has ever been compiled on the subject, as far as the State of Illinois is concerned. It contains a complete description of the minerals which now constitute the collection in the Illinois State Museum. It also gives a splendid idea to the reader of the science and principles of mineralogy. It is a subject on which the general public needs much enlightenment.

When the ordinary layman, for instance, visits a museum in mineralogy, he has very little conception of what the specimens are. They look and appear to him as just mere rocks. It needs a volume of this character to tell and explain to him just what the specimens are. He can not help but become interested by having knowledge of the matter that is contained in this book.

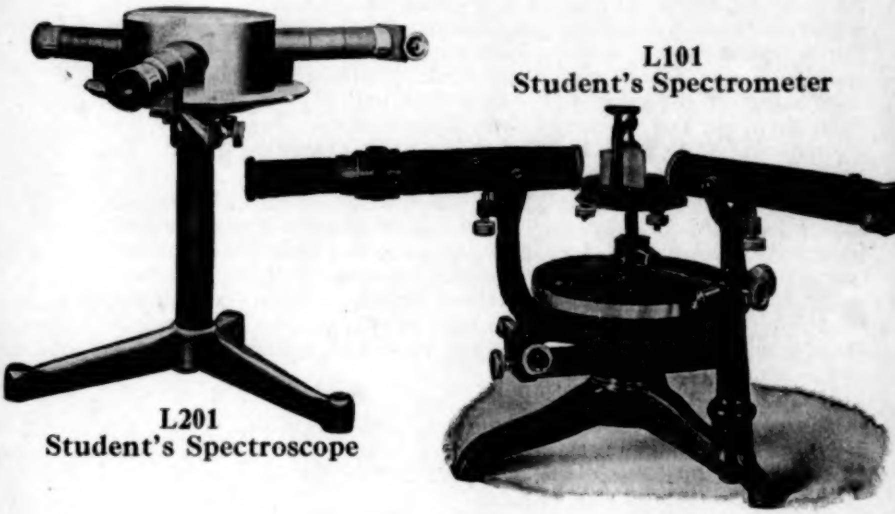
The text is profusely illustrated with half tones and zinc etchings (there are 236), most of them being original. It is splendidly written and can not help but be a tremendous aid in spreading the knowledge of the mineralogy of the State of Illinois. It is a book that will be of great value, which will bring before the general public the value of the mineral collections in our ever-increasing, interesting state museum. C. H. S.

Problems in Botany, by W. L. Eikenberry, Associate Professor of Education University of Kansas. Pages xii 145. Cloth. 14x21 cm. Illustrated with figures and tables. Ginn and Company, Boston and Chicago.

This laboratory manual marks a departure from the accustomed method of writing such books. It presents the work in the form of problems as the title of the book indicates. The problem is stated in the form of a question for the pupil to solve. The usual minute directions are wanting—instead the pupil has his problem stated, then is guided with general directions in solving it. Suggestive questions at pertinent points in the work stimulate thought and inquiry. A good feature of the manual is that the pupil is not over guided but left free to develop the problem to a large extent in his own way, thus preserving individuality.

References are given for readings with each problem. It strikes the reviewer as unfortunate that these references are to the Bergen and Caldwell textbooks of botany almost exclusively. Occasionally some other book is listed. We think this exclusiveness to a single line of books a mistake. It can hardly be maintained that these books always give the best exposition of the topics to be studied. There are many good reference books and bulletins that should be in the school library. Reference to these sources would stimulate the teacher to build up a library of helpful books.

The directions for work seem to be clear and concise and the materials usually simple and readily obtained. Tables and figures are used with the more difficult problems, particularly with problems involving experi-



L101
Student's Spectrometer

L201
Student's Spectroscope

ments. We note that the problems and directions are more suitable for small classes with which the author has had experience than for the large classes of city high schools. The teacher with large classes would have to adapt the directions to suit the situation. However, most teachers of botany are well aware of the fact that no manual or textbook should be followed literally. Any such book should be modified to suit the conditions of the school.

We note that there are no directions for field study of wild flowers, and directions for excursions are lacking. Young people have the collectors instinct and delight in making collections of all sorts. Fruits and seeds, wood specimens, mushrooms and many other plant parts are excellent subjects for this work. It adds much to the enthusiasm and is desirable in breaking the monotony of daily routine for young students. Directions for such work, including the mounting and preservation of the specimens, would be very useful.

In general the author has done a good piece of work for botany in secondary schools and has done it in a very creditable manner. The organization of the problems into chapters according to their relation to each other is excellent—much better by the way than the organization of the textbook which the manual is designed to accompany. Used with proper discretion, not slavishly, the book should be helpful and worth while. Where teachers prefer to write their own directions it will still be very useful as a source book for project work. We heartily recommend an examination of the book to teachers of botany. W. W.

Logarithmic and Trigonometric Tables, Revised Edition, prepared under the direction of Earle R. Hedrick. Pages xx+142. 13x20 cm. 1920. The Macmillan Company, New York.

To the tables of the former edition, which were conveniently arranged, have been added the following: Extension of tables of hyperbolic functions, haversines, factors of composite numbers and logarithms of primes, compound interest, compound discount, amount of annuity, present value of annuity and American experience mortality tables. In its present form this book of tables is one of the most convenient for the general student for use in problems of engineering, navigation, statistics, insurance, and accounting.

H. E. C.

Elementary Functions and Applications, by Arthur S. Gale, Ph. D., and Charles W. Watkeys, A. M., Professors of Mathematics in the University of Rochester. Pages xx+436. 13x19 cm. 1920. Henry Holt and Co., New York.

Of the several books recently published containing a year's work for college freshmen this seems to be one of the best. From the mathematical point of view it presents the meaning and use of functions of one variable, excluding complex variables, in a comprehensive and systematic way. Throughout it is the function that is emphasized and made familiar to the student; that it happens to be found in the field of algebra, geometry, trigonometry, analytic geometry, or calculus is only an incident. From the practical or applied mathematics point of view this method of dealing with problems develops the student's ability to work satisfactorily real problems that he may have to deal with, and gives him a better understanding of the usefulness of mathematics. The problems cover a wide range of material in elementary mechanics, physics, chemistry, economics, and other subjects of interest to students. These problems are especially serviceable in giving the necessary drill in setting up the function from the printed words. H. E. C.